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U.S. monetary policy and the exchange rate:
Effects on the world coarse grain market

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CHAPTER I. INTRODUCTION

The Problem

During the 1950s and 1960s, the United States benefited from relatively stable monetary policy. Inflation was low and shifts in monetary policy were few. This stability largely reflected the weakness of monetary policy as a domestic policy tool under the prevailing international monetary system of fixed exchange rates, known as the Bretton-Woods arrangement. Under fixed exchange rates, changes in the money supply of any country (except the U.S.), must be offset by adjustments in official reserves as the government attempts to hold the value of its currency constant (Stern, 1973).

At the same time, the U.S. agricultural sector was growing rapidly. This growth, however, was rooted in the strength of the domestic rather than the export market. Until the mid-1960s, the United States was a net importer of agricultural products and only a marginal net exporter through the late 1960s and early 1970s. Consequently, the relationship between the agricultural sector and monetary policy were not obvious, well-understood, or perhaps even significant. According to Schuh (1983), "the nature of our economic system was such that monetary policy had little effect on agriculture."

A number of events occurred in the late 1960s and 1970s that have greatly enhanced the impact of monetary policy on the agricultural sector. In fact, Schuh (1983) has argued that agriculture became one of the sectors of the U.S. economy that bears an important share of adjustments to changes in monetary policy. Following World War II, U.S. balance of payments (BOP) deficits served as a source from which the reconstructed nations of Western Europe and Japan replenished their stocks of international reserves (Grubel, 1977). U.S. balance of payments deficit problems intensified in the late 1960s as the money supply began to grow rapidly to finance the Vietnam War (Grubel, 1977). As U.S. deficits increased, the BOP surpluses of other countries grew.

The increasing U.S. deficit and the unwillingness of U.S. trade partners to revalue their currencies led the United States to devalue the dollar by almost 10% against special drawing rights (SDRs) and to close its gold window in 1971. The dollar devaluation sent a shock wave through the international community and set the stage for the demise of the Bretton-Woods arrangement. The final breakdown occurred in March 1973 when the U.S. devalued the dollar for a second time.

Following the move from fixed to flexible exchange rates, U.S. monetary policy became unstable as U.S. monetary authorities "embarked on zig-zag, stop and go monetary policies that appear to be still with us today" (Schuh, 1983). The increased volatility of the money supply led directly to increased volatility in the value of the dollar, and, hence, in U.S. prices and exports. Under a fixed exchange rate system, and in the absence of trade barriers, a change in the money supply that affects the domestic price level will result in a corresponding change in foreign prices, according to the Purchasing Power Parity doctrine. Under flexible rates, however, the same change in the money supply and corresponding change in domestic price levels is matched by an offsetting change in the exchange rate. As a consequence, the export sector of an economy bears a large share of the adjustment to changes in monetary policy.

At the same time that monetary policy became more unstable with a greater impact on the export sector, growth and prosperity of the U.S. economy as a whole, and the agricultural sector in particular, became increasingly dependent on a strong export performance. Currently, the output from about two out of every five acres of land is exported and over 27% of farm cash receipts come from exports. Consequently, the U.S. agricultural sector, its growth, and prospertiy have become closely linked to monetary policy.

Since the breakdown of the Bretton-Woods system, the relationship between the overall U.S. economy and the agricultural sector has become the center of a lively debate. A number of researchers have investigated various aspects of the macrolinkages to agriculture (Gardner, 1981). Nevertheless, most of this research has focused on the effect of exchange rate changes on agricultural exports and prices with little attention to the effect of changes in monetary policy on U.S. agriculture through their effects on the exchange rate. The following review of literature begins with a consideration of the post-1973 studies dealing with the macrolinkages of U.S. agriculture. This review will reveal that the primary focus has been on the exchange rate as an exogenous factor rather than as an endogenous monetary factor affecting U.S. agriculture.

Review of Literature

Schuh (1974) argued that since at least the early or mid-1950s, the explanation of "the U.S. farm problem" has been partially wrong because of the omission of exchange rates from the analysis. Using the induced technical change model of Hayami and Ruttan, Schuh argued that exchange rates play an important role in trade, in the valuation of resources within the U.S. economy, in the distribution of benefits of economic progress between consumers and producers, and in the way the benefits of technical change are shared between the domestic economy and the world.

Most analysts of the late 1970s listed the temporarily bad weather conditions outside the U.S., the decline of the Peruvian fish industry, and the sudden increases in U.S. exports to the Soviet Union as the economic factors responsible for the mid-1973 price explosion. Schuh's analysis, however, suggested that an important share of the rise in agricultural prices in that period was the result of an adjustment to a previously overvalued exchange rate which induced an export boom in an economy that was already responding to expansive monetary policies, and, in the case of agriculture, increased the foreign demand for U.S. output at the same time that this demand was already rising.

Much of the literature since 1974 has revolved around the size of the exchange rate elasticity of foreign demand for U.S. agricultural commodities. Articles by Vellianitis-Fidas (1975), Kost (1976), and Johnson, Grennes, and Thursby (1977) took serious issue with Schuh's conclusions. Vellianitis-Fidas referred to her econometric results stating that the U.S. wheat and corn exports are inelastic with respect to the U.S. exchange rate changes. Using a two-country, one-commodity free trade partial equilibrium analysis, Kost applied a theoretical model to graphically assess the impact of the exchange rate on U.S. agriculture. He argued that the impact of exchange rate changes on quantity is small when domestic demand and supply are inelastic. He further argued that because the elasticity of both supply and demand is very low, particularly in the short run, for U.S. agricultural products, a devaluation would generate relatively larger changes in price than in quantity traded for agricultural products as opposed to industrial goods. He also emphasized that the proportional increase in price or quantity of traded goods in response to a devaluation is restricted to being less than or equal to the percent of devaluation. Kost (1976, p. 104) concluded: "In summary, we can only expect a small impact on agricultural trade as a result of a change in exchange rates."

Using linear excess supply and demand curves, for a free trade, partial equilibrium, two-country, and one-commodity world, Bredahl (1976) concluded that, indeed, the elasticity of price with respect to the exchange rate ($E_{p,e}$) has no *a priori* lower bound. Bredahl's calculations suggested that the effect on price of a change in the exchange rate is greatest when excess supply is relatively less elastic, while the impact on quantity increases as the elasticity of excess supply increases. The change in quantity also increases as the elasticity of excess demand increases in absolute value so that the largest effect of a devaluation on the total value of exports occurs when both elasticities are relatively large.

Within this context, it was natural that discussion of the effects of changes in the exchange rate would focus, in part, on the question of appropriate values for these elasticities. Most attention, however, was paid to the price elasticities of the total excess demand facing the United States.

An important problem that arose in the empirical work was the wide range of estimates for the elasticity of the excess demand curve facing the United States. For example, using subjective values for domestic supply and demand price elasticities, Tweeten (1967) initially derived the price elasticity of the total export demand for U.S. agricultural commodities to be -15.9. However, after considering world trade restrictions, it was reduced to -6.3. At the same time, other direct statistical estimates of this elasticity were much smaller than those of Tweeten (see Stern, 1978).

The debate then focused on the discrepancy between the derived and direct estimates of the excess demand elasticity. Bredahl, Meyers and Collins (1979) argued that the government policies of major importers of U.S. commodities should be incorporated to arrive at a realistic estimate of the elasticity. They concluded that Tweeten's estimate of the elasticity of excess demand is simply not "in line with what is known about the world with insulated agricultural markets." They stated that trading behaviors (including government policies) affecting world price transmission should be considered directly. They showed that if "elasticity of price transmission"[1] is zero for a particular country, a change in world price, or a currency devaluation by an exporter would have no effect on the domestic markets in that country and, therefore, no effect on its import demand. Then, by assigning subjective values to the elasticities of price transmission of major importers of U.S. agricultural commodities, they calculated the price elasticities of total import demand for major U.S. export commodities. The estimates were much smaller than in the base case of perfect price transmission.[2]

The divergence in the conclusions of these studies

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[1]Elasticity of price transmission was defined as:

$ET = \frac{dP^{i}}{dP^{wld}} \cdot \frac{P^{wld}}{P^{i}}$, where P^{i} is the price in country i, and

P^{wld} is the world price.

If ET = 1, then the price transmission is said to be perfect.

[2]The estimated excess demand elasticity on the basis of implied elasticity of price transmission ranged from -.47 for soybeans, to -2.36 for sorghum, compared to -1.12 for soybeans, to -5.5 for wheat under the assumption of perfect price transmission for all importing countries.

concerning the effect of exchange rates on the agricultural sector also led to the belief that the difference in the outcome may be caused by alternative specification of excess demand and supply equations. One such study is by Chambers and Just (1979). They argued that excess demand and supply equations must include all prices and income, since neo-classical demand and supply functions are the results of utility and profit maximization. Their model treated all prices, the exchange rate, and income as demand shifters and all prices and the exchange rate as supply shifters. By changing prices of competing commodities, a devaluation will cause shifts of both the supply and the demand curves. Further, demand shifts need not be pure percentage shifts as is the case when the exchange rate is the only demand shifter. They concluded, therefore, that there is no a priori reason to expect the price or quantity change to be less in percentage terms than the change in the exchange rate.

The implication of their conclusions on empirical work was that the assumption of zero cross-price elasticity, i.e., exclusion of all other prices, distorts the elasticity estimates. Such an assumption presupposes that exchange rate movements and own-price movements in the exporting country have the same effect on excess demand. For example, Japan's decision about how much grain to import from the United States is probably determined to some extent by the volume of other imports from the United States and, to some extent, by the volume of its exports to the United States, both of which would be affected by an exchange rate devaluation.

In addition, Chambers and Just (1979) argue that there is further reason to believe that exchange rate movements should be differentiated from market price movements. Orcutt (1960) hypothesized that economic agents react more quickly to exchange rate changes than market price changes in a world of fixed exchange rates. This is because changes in the exchange rate under a fixed regime are perceived as being more permanent than short-term price changes. Also, exchange rate movements usually involve a larger percentage change than agricultural prices, which are usually subject to governmental pricing policies. Therefore, under a fixed exchange rate regime, adjustments may be faster to exchange rate changes than to price changes.

Lastly, based on their findings, Chambers and Just propose alternative approaches to model exchange rate effects. First, they assume commodities are separable into three groups: the good in question, all other tradable, and nontradable items. Then, they construct price indices for the second two groups and include them as separate regressors in the import demand function, along with own prices. The tradable goods price index is weighted by the exchange rate.

This approach allows one to account for the indirect cross-price elasticity effects on the good in question caused by a change in exchange rate.

A more practical approach is to include the exchange rate as a separate regressor to represent the index for all other tradable goods, since construction of the indices may likely be impossible. The Orcutt hypothesis suggests including the exchange rate directly in excess demand equations to reflect the differential effects of exchange rate and price fluctuations. In fact, if differential adjustments to price and exchange rate movement exist, one variable, say, deflated price, cannot represent both effects.

Chambers and Just concluded that: (a) any study of the effect of devaluation (revaluation) on demand cannot ignore the cross-price effects, and (b) the domestic price response to exchange rate disturbances may be (but does not have to be) different from the response to foreign price disturbances.

Grennes, Johnson, and Thursby (1980)[1] and Reed (1980),

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[1]This article was a response to Chambers and Just (1979) who had criticized the Johnson, Grennes, and Thursby (1977) model as "equivalent to a simple one-good model." The latter was a multi-country trade flow share model (Armington, 1969) to account for the cross elasticity effects among countries for wheat. Although later agreeing with Chambers and Just (1979) that prices of complement (substitute) and nontradable commodities should be included, Johnson et al. did not include those variables in their 1977 analysis. The estimated impact of the exchange rate movements on U.S. wheat price was small, apparently because they had assumed a small value (.3) for the cross-elasticities. The supply of wheat and the exchange rate were exogenous in their study.

however, argued that the structural excess demand relationship should not be distorted in order to capture the full effect of a change in exchange rate. They argued that economists must either model the entire economy of the countries in question or settle for a partial-effects estimate of exchange rate. According to Grennes, Johnson, and Thursby (1980): "Whether the benefits of a larger model are worth the cost in terms of additional complexity is a question without an easy answer."

Reed (1980), while agreeing with the substance of the Chambers and Just article, objected to inclusion of a weighted price index of other tradable goods, insisting that the Purchasing Power Parity theory may not hold. Instead, Reed proposed to include an index of all domestic prices and prices of commodities judged to be close substitutes (complements) to circumvent the problems of cross-price effects on the good in question. He indicated that constructing an index of nontradable goods for all countries requires much data which are not necessarily available. Therefore, inclusion of an index of all domestic prices to account for cross-price effects of nontradable goods on the excess demand is the best that can be done. In addition, Reed indicated that for each and every price of a commodity included separately as a relatively close substitute (complement), a purchasing power parity equation should be included.[1] If purchasing power parity does not hold, he proposed a base period exchange rate series instead of yearly observations (Bjarnason, McGarry, and Schmitz, 1969).

Reed also indicated that inclusion of the exchange rate as a separate variable to account for cross-elasticity effects of other tradable goods, as was suggested by Chambers and Just, is appropriate for short-run analyses under a fixed exchange rate regime because the assumption for this specification is that the exchange rate and the world price affect the domestic price unequally. Only in the short run and with fixed exchange rates can a change in exchange rate be viewed as a more permanent development than a change in the world price. That is, an exchange rate change is less likely to be reversed than a change in the world price. Therefore, adjustment to an exchange rate change may be more rapid than an equal change in the world price.

In the long-run, there is no uncertainty as to the permanence of either an exchange rate or a world price change and, consequently, there is no difference between exchange rate and world price variations of equal magnitude, even under

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[1]Purchasing power parity requires that $P^i = e \cdot P^j$, where: P^i is the nominal price level in country i, P^j is the nominal price level in country j, and e is the price of the jth country's currency in terms of the ith country's currency.

a fixed exchange rate regime. Nevertheless, differential response lags for exchange rate and world price changes may be different. To account for these differential response lags, a distributed lag framework with a constraint (that the sum of the weights for the coefficients of the two regressors be equal) has been used by Wilson and Takacs (1976).

From the foregoing review of the exchange rate literature, three salient points emerge with respect to the empirical measurement of the effect of exchange rate changes on world agricultural market prices and quantities. First, the behavior of all world market participants must be included in the model utilized. Second, in addition to the own price and income variables, the prices of the substitutes (complements), and nontradable commodities must be included in the excess supply and demand functions in the model. Third, insulating governmental policies must be taken into account in the model.

An empirical analysis of the world market effects of U.S. exchange rate changes (fixed or flexible regime) requires a multi-national trade model. A number of such models of agricultural trade have been built and surveyed in several studies. For example, Adams and Klein (1978), Adams and Behrman (1978), Grennes, Johnson, and Thursby (1977), Labys (1973, 1978), Sarris (1981), Schmitz (1979), Schuh (1979), Thompson (1981), and Rausser (1983) all reviewed the methodologies/applications of many such models. Thompson classifies the models into three groups: spatial, nonspatial single homogeneous, and nonspatial differentiated product models.

The intended use of the model dictates the appropriate choice of the methodology. Table 1.1 presents a matrix indicating various economic and policy questions and alternative empirical methods best suited for dealing with them.

As mentioned earlier, the analysis of exchange rate impacts requires the explicit specification of the world market participants' behavior in the model. Thompson explained that nonspatial equilibrium models can be used to explain the interrelationships among trading regions by including the structure of the internal demands and supplies, government behavior, and the competitive structure of the industry. Past efforts to this end, however, have had some serious deficiencies which are best summarized by Thompson (1981). He observes that some models of this type have internal demand and supply while others contain only export supply or import demand relationships for each region.

A serious deficiency of many of these models is their negligence in including trade policies, given the considerable extent of tariff and nontariff interventions. Thompson indicates that distortions can easily be introduced into

Table 1.1. The relevance of the various empirical trade models to some policy questions (Sarris, 1981)

	Nonspatial Price Equilibrium Models	Spatial Price Equilibrium Models	Armington-type Models
Price formation	X[a]		
World price forecasting	X	X	
Trade pattern		X	X
Impact of trade restrictions	X	X	X
Commodity agreements	X	X	X
Cost and benefits to trading countries	X	X	

[a]The symbol "X" means that the models are appropriate or have been used to deal with the problem.

simultaneous equation models. Domestic government policies are another neglected factor in many of these models. Considerable evidence exists that domestic policy decisions are not exogenous to commodity markets and, therefore, should be endogenized. Thompson explains that policy reaction functions and price transmission equations can easily be used to account for this endogeneity. Two other important endogenous variables have also been treated as exogenous: freight rates and currency exchange rates. Because of data unavailability, however, a major difficulty exists in including freight rates.

The exogenous treatment of the exchange rate in world trade models has been criticized by Schuh (1981) and Chambers and Just (1981, 1982), as well as others. Schuh (1981) argued that since 1973, three interrelated factors have greatly influenced the international world market: (1) growing internationalization of agricultural commodity markets, (2) increased integration of international capital markets, and (3) the shift from a system of fixed exchange rates to a system of flexible exchange rates.

Under fixed rates, external disequilibrium is offset by government actions to peg the exchange rate. Therefore, monetary policy affects the markets only through domestic channels. Furthermore, a fixed exchange rate can be viewed as a policy tool which can be influential only when altered. Under a flexible regime, however, the rates are a function of numerous variables, of which monetary and fiscal policies are the most important. See Chapter II for the details of this link.

Many others have emphasized this link empirically. Shei (1978), for example, simulated the impacts of the U.S. money supply on the U.S. farm sector. However, since the exchange rate was assumed to be fixed, the link between the money supply and the exchange rate was eliminated. Barnett et al. (1981), using the Granger Causality Test, showed the causality relationship between agricultural prices and the U.S. and world money supply. Epstein and Chambers (1981) found evidence of a causal relationship between the exchange rate and agricultural trade. Chambers and Just (1981) used a U.S. agricultural model of corn, soybeans, and wheat to show the effect of the money supply on the prices, production, and disappearances of all three commodities. While they treated the exchange rate as endogenous, they did not include the prices of all substitutes (complements) and nontradable goods to appropriately account for the impacts of the exchange rate. In their 1982 article, an attempt was made to do so. However, they stated that the data to construct the variables suggested as proxies in their 1979 paper could not be found. Consequently, they applied Reed's (1980) suggestion of using the index of all other domestic prices as the proxy.

The most recent analysis of monetary policy on agriculture is by Chambers (1984). He develops a theoretical model based on financial and commodity sectors of an economy. However, the model is of a short-run nature and not capable of addressing long-run outcomes of a policy change. He also shows that an expansionary monetary policy may improve the competitive position of an exporting-oriented sector in the short-run.

In summary, construction of a theoretically sound model of the world market for a given agricultural commodity would require the incorporation of the following:

1. the behavior of all world market participants;
2. endogenously determined domestic and trade policies of all market participants;
3. all other prices;
4. endogenously determined exchange rate and freight rates; and
5. differentiation of the traded commodities by source of supply.

This, of course, is a formidable task and would require a large and detailed multi-national, and multi-sectoral model.

Objectives

The general concern of this study is the effect of U.S. monetary policy on U.S. agricultural exports and U.S. export market share through its effect on the exchange rate. Although the theoretical literature in agriculture on this topic is expanding, relatively little attention has been paid to the instability caused by monetary policies through their effect on the exchange rate. In general, multinational models have treated the exchange rate as fixed and ignored the effects of monetary policy (Thompson, 1981).

The specific emphasis of this study will be U.S. monetary policy and its impacts on the world coarse grain[1] market. The U.S., as a world banker and a large country, dominates world money supply, world inflation, and exchange rate movements (Dornbusch, 1980, pp. 140-141). Small countries have only a minor effect on world inflation and exchange rates. In addition, only a few countries of the western world have floating currencies. In June of 1980, for example, only 39 of the 133 member countries of the International Monetary Fund had floating rates. Of those, 9 kept the rates within a defined band and some 95 members pegged their currencies either to a single other currency (predominantly to the U.S.

[1]The definition of "coarse grain" is provided in Appendix A.

dollar) or to the Special Drawing Rights. For this reason, the present international monetary system is often called a "dirty" or "mixed" floating regime of exchange rates. Therefore, exchange rate control by a large number of countries, after March 1973, has limited the effects of their monetary and fiscal policies on exchange rates. The econometric model developed here will, therefore, be a partial equilibrium model in that only U.S. monetary policy effects on the world coarse grain market will be considered.

The coarse grain market is used for several reasons. First, since the mid-1960s coarse grain has been the world's largest grain commodity in terms of production, consumption, and trade (see Wisner and Denbaly, 1982). Second, coarse grain is utilized mainly by the developed nations as a livestock feed to meet their increasing demand for meats. This helps reduce the size of the model by limiting the number of significant participants in the world coarse grain market. The United States, Argentina, Canada, Australia, South Africa, and Thailand are the six largest exporters of coarse grain. Together, they exported around 85% of total world trade in 1982. The U.S. accounted for 72% of world coarse grain exports, followed by Argentina which supplied only 9.5%. On the importing side, the European Economic Community (EEC), Japan, the USSR, Eastern European, and Low-Income Less Developed nations are the largest world market participants.

The EEC and many other participants, however, can be treated as exogenous, because of their effective price insulating policies. Common Agricultural Policy of the EEC, for example, has not permitted world market signals to penetrate the domestic market (Chapter II for details). The remaining regions have been relatively small and thus, unimportant.

Only two world coarse grain trade models exist in the literature, neither of which is suitable for the general purposes of this study. Bjarnason (1967) used a spatial equilibrium model to forecast prices, production, consumption, and trade flows for the year 1980. Comparisons of his forecasts (see Bjarnason, 1967, p. 220) and actual 1980 data indicate that a large error is generated in forecasting those variables, particularly the trade flows. This is not surprising because much has happened since 1967, for which this spatial model was not designed. Thompson (1981) indicates that nonspatial equilibrium models are most appropriate to explain the interrelationships among trading regions by including the structure of the internal demands and supplies, government behavior, the competitive structure of the industry, exchange rates, etc. Collins (1977), used an Armington (1969) type model known as a trade flow and market share model of world coarse grain trade. Sarris (1981) indicated that Armington type models are not designed to answer questions relating to price formation and forecasting.

Therefore, Collins model cannot be used to explain (or forecast) the effects of U.S. monetary policy through exchange rates on price formation and trade in world coarse grain markets.

The specific objectives of this study include the following:

1. qualitative study of U.S. monetary policy (during the 1960-1980 period) and its general internal and external influence;

2. investigation of the channels through which U.S. monetary policy influences agricultural commodity markets;

3. research of the quantitative characteristics of world coarse grain market participants and a description of their historical policies;

4. conceptualization of a nonspatial world coarse grain market model, including specification of demand, supply, and inventory equations for countries which are important in terms of their quantitative characteristics and historical pricing policies, and specification of import/export demand relationships for the remaining regions;

5. validation of the model by (a) historical simulation, and (b) stability test. The model's stability is measured by its response to a one period exogenous shock in the U.S. money supply in 1971;

6. simulation of the model to analyze the effects of an expansionary U.S. monetary policy. Because of the move from fixed to flexible exchange rates in the early 1970s, the analysis is performed for the decade of the 1970s to assess the impacts of a sustained five billion dollar increase in the U.S. money supply on the prices, trade, and U.S. production, consumption, and inventory of coarse grain.

Data Sources

The majority of the data in this study are published by the United States Department of Agriculture. The remaining data have been collected from various sources. Chapter IV provides the variable names, definitions, units, and the sources of the data used.

The data for the centrally planned economics were the most difficult to obtain. The Central Intelligence Agency publication Handbook of Economic Indicators was the single most useful source for these data.

The data for the U.S. exchange rate were obtained from International Financial Statistics published by the International Monetary Fund (Table 4.2 for detailed data sources).

Organization of this Dissertation

Chapter II reviews the history of U.S. monetary policy and the channels through which U.S. monetary policy affects commodity markets. Chapter II also describes the supply and demand structure of the world coarse grain market, including the domestic and trading policies of the regions of the model.

Chapter III includes two subsections. First, the general structure of the model is discussed graphically.

Second, the mathematical representation of the model including the theoretical construction is presented.

Chapter IV reports the characteristics and properties of the model, appropriate estimation procedure, the final estimated equations, and the validation results.

Chapter V is devoted to the simulation results. Finally, Chapter VI includes a summary, conclusion, and suggestions for further research.

CHAPTER II. DESCRIPTION OF U.S. MONETARY POLICY AND THE INTERNATIONAL COARSE GRAIN MARKET

The purpose of this chapter is to describe U.S. monetary policy, the world coarse grain market, and their interrelationship as a background to the empirical analysis of the effects of monetary policy on trade in the next chapter. The chapter is divided into two main sections: 1) the process of U.S. monetary policy, its history, and linkage to agricultural commodity markets, and 2) the structure of the international coarse grain market, with emphasis on the domestic and trade policies of the market participants.

U.S. Monetary Policy

The U.S. money supply changes in response to actions by the Federal Reserve Bank (FRB) and government fiscal policy. In this section, after considering the various sources of changes in U.S. money supply, the transmission mechanism of U.S. monetary policy actions to the U.S. exchange rate changes and the linkage to agricultural commodity markets are explained.

Sources of the U.S. money supply

Monetary policy instruments   The FRB can affect the level of the money supply in three ways, all operating through the reserve requirement mechanism. This mechanism requires commercial banks to hold as reserves some fraction of their total demand and time deposit liabilities, that is, of their customers' total checking and savings account balances.

First, the reserves can be altered by the FRB's open market operations. The decision to buy or sell is made by the FRB's open market manager, usually a vice president of the FRB of New York, under the supervision of the Open Market Committee, composed of the seven FRB presidents. If the FRB decides to buy government bonds, it can do so by drawing checks on itself. The sellers of the bonds will then deposit the checks, drawn on the FRB, in their local banks. These checks then become the local banks' claims on the FRB, or reserves from the local banks' point of view. Until late 1979, these types of policies were used by the FRB as a policy tool to influence the nominal demand for money through its effect on interest rates.

Second, money supply is affected through what is known as the discount window operation. Commercial banks may borrow reserves from the FRB at a specified discount rate, normally set below the short-term market interest rate--such as a treasury bill rate. Like the FRB purchase of bonds, commercial bank reserve borrowing increases the money supply. The difference is that open market operation is initiated by the government, while the discount window operation is initiated by the private sector.

Third, the FRB can also influence the money supply by altering the reserve requirement ratio. A decrease in the reserve ratio will enable commercial banks to expand their demand deposit liabilities and therefore increase the money supply. For details of this process see Beare (1978).

These three monetary policies of the FRB are often applied in different circumstances to serve different purposes. The open market operations are viewed as the FRB's daily practice of controlling the money supply (Branson, 1979, p. 269). Before 1980, open market operations were used to control the interest rates. Currently, however, this instrument is used to control the money supply to affect the rate of inflation and other economic indicators. The discount window operations are basically designed to help commercial banks under tight monetary conditions by allowing them to borrow reserves from the FRB. Therefore, they are defined within the context of overall credit conditions set by the FRB. A change in the reserve ratio, however, is viewed as a major shift in monetary policy, and is therefore, well-publicized by the FRB to serve as a warning signal to the financial community.

Deficit financing The effects of deficit spending on the money supply depend upon the way in which the deficit is financed. There are basically four ways through which the government can finance a deficit. First, the government can sell bonds to either the nonbank public or commercial banks. The treasury deals directly with the private sector; consequently, this has no effect on either reserves or the money supply. Second, the government can sell the bonds to the FRB in exchange for deposits. As a result, the money supply increases because the treasury spends these funds by transferring the deposits to the public, who then transfers them to their banks in exchange for demand deposits. Third, the treasury can finance the deficit by using up its demand deposits in the commercial banks. Because the demand deposits held by the government are not counted as part of the money supply, this method of deficit financing also increases the money supply. Finally, the treasury can use its deposits with the FRB which will also increase the money supply.

The unwillingness of the U.S. to tax itself to finance the Vietnam war led to an increasing budget deficit as the government sold bonds. Consequently, the U.S. money supply also began to increase, putting a strain on the dollar-gold par value, supported by the U.S. under the Bretton-Woods arrangement, and, therefore, on the international monetary system. Furthermore, through its effect on the money supply, deficit spending has had a greater impact on the exchange rate, with the beginning of floating exchange rates.

The U.S. government has attempted to affect (and control) the rate of growth of aggregate demand through its demand-management-type macroeconomic policies since World War II.[1] The macroeconomic policies affect aggregate demand in two stages. For example, an increase in the real money supply first generates a portfolio disequilibrium in the money market. That is, at the prevailing interest rate and level of income people are holding more money than they want. This causes portfolio holders to attempt to reduce their money holdings by buying other assets; the change in the money supply changes interest rates. In the second stage, the change in interest rates affects aggregate demand.

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[1]The ultimate goal has been to manage the rates of unemployment and inflation.

History of U.S. monetary policy: 1960-1980[1]

The term "New Economics" has been used to describe the analytical and philosophical approach to economic policy-making during the Kennedy and Johnson administrations in the 1960s (Dornbusch and Fischer, 1981). The philosophy has come to be known as one of the most activist and optimistic approaches to economics. It is well-characterized by Walter Heller (1967):

> The significance of the great expansion in the 60's lies not only in its striking statistics of employment, income, and growth but in its glowing promise of things to come. If we can surmount the economic pressures of Vietnam without later being trapped into a continuing war on inflation when we should be fighting economic slack, the "new economics" can move us steadily toward the qualitative goals that lie beyond the facts and figures of affluence.

The first major economic policy action taken by the Kennedy-Johnson administration was the 1964 tax cut. The 20 to 91 percent marginal tax rates for individuals were cut to 14 to 70 percent. Similarly, the corporate tax rate was reduced from 52 to 48 percent (Heller, 1967, pp. 61-70). The total tax cut was estimated to be 13 billion dollars. The vigorous expansion in economic activity set off by the 1964 tax cut and supported by accompanying monetary

[1] A more detailed analysis of macroeconomic policy actions and their impacts upon the macroeconomy can be found in Dornbush (1981), from which this summary has benefited.

expansion led to a significant increase in inflation by 1965-66.[1] Inflation rose from an annual rate of 1.0 to 1.5 percent during 1961-64 to about 2.9 to 5.4 percent during 1966-69. Unemployment fell to 4 percent by early 1966, and the economy was operating at a high level of GNP.

The high inflation rate led to a restrictive monetary policy that produced the credit crunch of late 1966. The money supply stayed constant for the last three quarters of 1966 from a 4.5 percent rate of growth in early 1966. The reduction in the growth rate of money supply was the result of not only a reduction in the rate of growth of high-powered (base) money but also an increased reserve requirement on time deposits. At the same time, Regulation Q imposed a ceiling on interest rates that banks are allowed to pay on their time deposits. As the credit crunch pushed up nominal interest rates rapidly, commercial banks found themselves incapable of raising funds because the public preferred other assets yielding higher returns than the regulated time deposits. The consequent tightness of the monetary supply affected aggregate demand, particularly residential construction, and was reflected in the real aggregate output reduction of the U.S. in late 1966 and early 1967.

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[1]All rates of growth of money supply used in this section are on a December to December basis.

The "minirecession" of 1966 (Dornbusch and Fischer, 1981) was followed by large military spending, in addition to highly expansionary monetary policy during 1968-69. The rate of growth of the money supply increased from 2.2 percent in 1966 to around 7 percent during 1967-68. As a result, inflation increased from 3 percent in 1967 to 4.7 percent by late 1968. Dornbusch and Fischer (1981) give two reasons for this highly expansionary policy. First, the FRB was attempting to avoid a repetition of the credit crunch. Second, the effects of the 1968 tax surcharge in reducing aggregate demand were overestimated. The surcharge was designed to offset the large expansionary effects of the sizeable defense spending during 1965-67, which was coupled with no expansionary monetary policy. In other words, the high level of employment combined with the increasing rate of inflation in 1967 led to the 1968 tax increase to offset the expansionary effects of high levels of government spending.

In 1969, in an effort to reduce inflation, which reached an annual rate of about 5.0 percent a year, the rate of growth of the money supply and government deficit expenditure were reduced. The result was the 1969-70 recession and a reduction in real output. In 1972, while a system of price and wage controls was in effect, the money supply and government deficit spending were increased. The money supply growth was increased to 9.3 percent, leading to an increase in aggregate demand and, therefore, real output. Between 1972 and 1974, money supply growth was reduced from 9.3 to 4.4 percent a year, leading to the longest and most severe economic contraction of the post-war period (Starleaf, 1982). The real output of the economy rose again between 1975-1978 for at least two reasons: 1) the 1976 tax cut recommended by the Ford administration and 2) a substantial increase in the rate of growth of the money supply. From about 5.0 percent in 1975, the annual rate of growth in the money supply increased to 8.3 percent in 1978. As mentioned earlier, however, the Federal Reserve authorities adopted a tight monetary policy in 1979, which ended in 1982. The December-to-December M1 money stock was reduced from 8.3 in 1976 to 5.6 percent in 1981. According to Starleaf (1982):

> This is the major causal factor for the business cycle contraction of 1980 and for the cyclical contraction which began in July 1981.

As is evident, monetary policy has been used by policy-makers to influence the rates of inflation and unemployment. In the first section of this chapter, processes of altering money supply were discussed. Then, the recent history of U.S. monetary policy was discussed. The following section is a discussion of the links between monetary policy and agricultural commodity markets.

Monetary policy and the agricultural commodity markets

Starleaf (1982) illustrates that the impacts of monetary policy on commodity markets are realized through both foreign and domestic channels. Each of these will be discussed in turn.

The extent of the impact of the monetary policy on commodity markets through foreign channels depends upon the prevailing international monetary system. Under the Gold-Standard and the Bretton-Woods systems, the United States was committed to preserving the price of gold, while other currencies were linked to the U.S. dollar. With weak international financial capital markets, this meant that as the U.S. money supply increased, the commitment to preserve the gold-dollar par value eventually became impossible. This was because the U.S. gold stocks were becoming unmatchable to the stock of U.S. dollars at the fixed dollar price of gold, especially when other currencies were indirectly fixed to the gold price in terms of the dollar. Consequently, in 1973, after two devaluations, the Nixon administration broke away from the Bretton-Woods system. By this time, the fundamental idea of the monetary approach to exchange rate determination was established: an exchange rate, like the price of any commodity, changes as the total excess demand (demand minus supply) for the currency changes. Therefore, it was evident that exchange rates were a monetary phenomenon and even more importantly, that monetary policy independency was at stake if the fixed exchange rate regime was to be kept.

Under the Purchasing Power Parity doctrine, inflation is easily transmitted among countries under a fixed exchange rate system. Therefore, changes in the money supply of a country, given other variables, left the relative prices unchanged. This meant that under the fixed exchange rates, U.S. monetary policy did not affect the effective foreign demand for the industries active in trading. However, a monetary policy did profoundly affect the nontradable goods industries and the production of the trade sectors through its impact on internal interest rates.

The almost simultaneous evolution of the internationally integrated mobile capital markets and the (dirty) floating exchange rate regime dramatically changed the picture. The floating exchange rate regime was suggested by Schuh (1979) to be an important source of instability in the trading sectors of an economy. The flexible exchange rate system allows different rates of inflation to exist throughout the world. At the same time, under this system, monetary policy translates into exchange rate movements, particularly when capital is mobile. For example, a monetary expansion policy puts downward pressure on interest rates causing a capital outflow which ends when interest rates are equalized among countries. As a result of the outflow, the value of the domestic currency in international capital markets declines. The depreciation of the domestic currency makes imports decline while providing a stimulus to exports. The demand for domestic output would consequently increase, and adjustments in the trade sectors would be the means by which authorities achieve their goals. The external impacts of domestic monetary policy on the agricultural prices and exports are documented by Chambers and Just (1982).

Under flexible exchange rates, the external balance, i.e., the balance-of-payments, clears by adjustments in exchange rates. This self-correcting mechanism of the balance-of-payments provided a great deal of independence in terms of the monetary policies of trading countries. As a result, since the switch to flexible rates, the world money supply has dramatically increased. Individual countries wishing to increase their rates of employment and growth found monetary policy an effective tool under the floating rates. McKinnon (1982) and Frankel and Johnson (1976) have argued that the U.S. and world bouts of inflation and recession are better explained by wide swings in world money supply than they are by movements in aggregate domestic supply alone.

As noted earlier, the external impact of monetary policy under flexible rates is greatly enhanced, while the impact under the fixed rates is purely domestic. However, the domestic impacts of monetary policy under both regimes are profound. Starleaf (1982) documented the internal impact of monetary policy on agriculture. He showed that the annual variability of real and nominal output of the nonfood sector of the U.S. economy for the period 1948-81 were parallel. However, this was not the case for the food sector during the same time period. To quantify this impression, Starleaf used the standard deviations of nominal and real annual output changes for both sectors. In the nonfood sector, the standard deviations of annual percentage changes were 3.8% and 3.2% for nominal and real, respectively. At the same time, the standard deviations of nominal and real annual food sector output percentage changes, were 12.8% and 3.7%, respectively. These results, of course, are not surprising because agricultural supplies for each period are determined by the decisions made in the previous period and, therefore, are fixed at the beginning of each period. What is interesting, however, is that any time monetary policy was used to improve employment or to reduce inflation, nominal agricultural prices reacted dramatically. This occurred because the real output of the nonfood sector (unlike the food sector) was price elastic and, thus, reacted quickly putting upward pressure on the prices of the fixed agricultural supply of that period. Starleaf believes that the adoption of a tight money policy in late

1978 or early 1979, which ended in 1982, resulted in the business cycle contractions since 1980.

Until 1979, the FRB followed a demand-oriented monetary policy through the bonds market, using open market operations. Today, however, the main FRB objective is to control the supply of money. Given the growing deregulation of the U.S. credit and banking systems, the agricultural sector as a whole will be even more sensitive to monetary policy. As was illustrated, the effects of monetary policy through its effect on the exchange rate is quite different under different exchange rate regimes. In a later chapter, a model of the U.S. exchange rate is constructed as part of a world coarse grain market to account for the changes in the supply of money. In other words, an attempt is made to isolate that portion of the instability in the world coarse grain market that has been caused by freely fluctuating exchange rates.

Exchange rate fluctuations, as a monetary phenomenon, can be explained via the money market and Purchasing Power Parity doctrine. This means that not only money supply but also real money demand influence the exchange rate. In the absence of tariffs, transport costs, an exchange rate equates the prices of traded goods in alternative currencies as follows:

$$P = eP^* \qquad (1)$$

where P and P* represent the domestic and foreign currency prices of traded goods, respectively, and where e is the domestic currency price of foreign exchange.[1] Equation 1 can be solved for the exchange rate in terms of price levels:

$$e = \frac{P}{P^*} \tag{2}$$

To link the exchange rate to the monetary sector, money market equilibrium conditions of both countries are needed:

$$MS = P \cdot L(r, Y) \tag{3}$$

$$MS^* = P^* \cdot L^*(r^*, Y^*) \tag{4}$$

where MS and MS* represent the domestic and foreign nominal money supply, L and L* represent the domestic and foreign real demand for money which are functions of the relevant country's interest rate (r or r*), and real income (Y or Y*).

By solving for P and P* from (3) and (4) and substituting into Equation 2, the equilibrium exchange rate can be expressed as:

$$e = \frac{MS}{MS^*} \cdot \frac{L^*}{L} \tag{5}$$

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[1]Variables with asterisks refer to a foreign country.

The rate of change in the equilibrium exchange rate can then be expressed as:

$$\dot{e} = (\overset{(+)}{\dot{MS}} - \overset{(-)}{\dot{MS}^*}) + (\overset{(+)}{\dot{L}^*} - \overset{(-)}{\dot{L}}) \tag{6}$$

The first term in (6) represents the effects of nominal money supply changes on the exchange rate. Given other variables, it implies that an increase in the growth rate of nominal money supply in either one of the two countries will have a depreciating effect on its currency.

The second term in (6) captures the effects of changes in real money demand. Other variables constant, an increase in the growth rate of real money demand in either one of the two countries will have an appreciating effect on its currency.

The remainder of this chapter is devoted to an analysis of the international coarse grain market, the importance of the active participants, and their relevant domestic and trading policies.

International Coarse Grain Market

In order to capture the economic behavior of the world coarse grain market in an econometric model, the structure of the market and the interaction among market participants must be analyzed. Many studies in the area of agricultural trade have emphasized the influence of domestic agricultural policies on international market behavior. McCalla and Josling (1981), for example, emphasized the interaction of policy-determined (not market-determined) excess demand and supplies of all participants in trade. They concluded that the international market in grains is the interaction of policy-induced residuals from national markets, and that the principal objective of most domestic policies is to export domestic instability.

It is often argued that the U.S. dominates international grain markets as a price leader. Harrison (1980), for example, states that the U.S. sets the world prices through its domestic pricing policies and by acting as the residual supplier. Other exporters have operated in their own best interests within that environment.[1] He further argues that the net effect has been an oligopolistically competitive structure with U.S. price leadership and market sharing among other supporters. Paarlberg (1980) wrote:

> We pursued policies that made us unfortunately the residual supplier in world markets. We held our export prices above world levels. Other exporters priced their products a cent or two under ours and sold their supplies. Buyers would purchase these bargain products first, then turn to the United States to round out their needs.

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[1]For a full explanation of the "residual supplier" argument see Hillman (1981).

One analytical and two empirical articles have considered the role of the U.S. as a residual supplier in the international coarse grain market. McCalla (1967) postulated a theoretical model of coarse grain trade influenced by the domestic policies of major importers and exporters. He argued that the U.S. Commodity Credit Corporation's stock acquisition and dispersal policies set the price in the world market and that the United States can be considered the residual supplier in the world market.

Using a dominant-firm, price leadership empirical model, MacGregor and Kulshreshta (1980) conclude that the U.S. coarse grain demand curve consists of the residual of the world import demand left after small exporting countries sell all they want. In addition, they state that the U.S. would maximize its export revenues by restricting marketings.

Bredahl and Green (1983) also empirically explore the United States' role as a residual supplier in the world coarse grain market. Using the Granger-Sims Causality Test, they conclude that the hypothesized role of the United States as a residual supplier requires that coarse grain exports of competing exporters have not responded to world prices. They showed not only that the excess supplies of the competing exporters are price inelastic, but also that U.S. coarse grain exports and world prices are simultaneously determined.

For the purpose of the present study, the U.S. will be treated as the residual world supplier in the coarse grain market. However, because it is likely that a certain degree of price transmission would occur, prices will be linked among exporting and importing countries through a set of price transmission equations.

Regional breakdown of countries

Exporting regions Although there are well over a hundred countries that import coarse grains, there are only a handful of world exporters. The United States, Argentina, Canada, Australia, South Africa, and Thailand accounted for over 85% of the world's total coarse grain exports in 1982. Since 1972, the United States, consistently the largest exporter of coarse grains, has accounted for over 60% of total world exports, while the other five have accounted for about 25% of the world coarse grain exports.

Importing regions To reduce the number of importing countries in the analysis to a more manageable number, some classification system is normally used. Geographic and economic classifications are the two most commonly used divisions. However, as Schmitz et al. (1981) indicate, similarities in market behavior and response must be used as the criteria for effective classification in economic analyses.

The importing regions range widely in size, per capita income, and international liquidity. This study uses the widely adopted tripartite classification, i.e., developed (DC), developing (LDC), and centrally-planned (CP) economies (see Appendix A). However, for the analysis of U.S. monetary policy impact on trade and prices, the diverse triparite aggregation does not quite suffice. The effect of change in exchange rates, as well as other variables, is to either shift or rotate the excess demand or supply schedule faced by an individual country. Hence, aggregation over a large number of countries does not allow taking account of such shifts explicitly. Following Schmitz et al. (1981), the criteria used in grouping importing nations are the similarities in price response, government policies, production, and export ability.

Developed countries (DC) are all high income countries. However, significant policy differences exist. Within the DC category there are three subdivisions: the European Economic Community (EEC), the remainder of Western Europe (OWE), and Japan. OWE pursues domestic policies similar to the EEC with its Common Agricultural Policy. Because the EEC and OWE have successfully insulated their domestic agricultural markets from the world market, they will be treated as an exogenous part of the model. Japan is treated as a separate region because it relies almost entirely on foreign sources of feed grains and is a relatively large importer.

The centrally planned countries are subdivided into the USSR, China (PRC), and Eastern Europe (EE). The USSR and China are considered as two separate regions because of the size of their production and trade. Vietnam, Cuba, North Korea, Cambodia, and Laos are included in the Developing Economies (LDC) category. This is because their import demand characteristics and responses resemble those of low-income nations with foreign exchange limitations.

To further divide the remaining countries, the criteria used by the International Food Policy Research Institute for long-term projections is applied. The two major influencing factors in imports of commercial goods include per capita income and foreign-exchange-earning abilities of the countries. Using this criteria, LDCs are divided into two subregions: the rapidly developing nations (LDCR) and the moderately developing countries (LDCM). The LDCR have an annual per capita income of at least $300. This subregion is further divided into OPEC and non-OPEC (NONOPEC) countries. The LDCM have a per capita GNP of less than $300. Note that the five centrally planned countries excluded from the CP category are included in LDCM. For a detailed breakdown see Appendix A.

Quantitative characteristics and policies of the regions

International trade in grains has grown rapidly over the post-war period. This has been accompanied by significant changes in market structure. Increasingly fewer exporters provide grain to a growing and diverse set of importers. Trade has been heavily influenced by the decisions of national governments. This section first focuses on the key quantitative characteristics of the coarse grain market such as exports, imports, and market shares. Then the policies of the major participants will be considered.

Both in volume and value, coarse grain is the largest world production aggregate. World coarse grain production increased 62 percent over the twenty-one year period of 1960 to 1980 although the harvested area increased by less than 8 percent. A 56 percent growth in yields (1.6 to 2.5 tons per hectare) accounts for most of the increase. Trade rose rapidly over this period, mainly reflecting rapid increases in livestock feeding by importing, developed countries. The nearly 440 percent increase in trade between 1960 and 1980 resulted in an increase in the proportion of world production traded from 6 to 14 percent (Table 2.1).

Degree of international market dependence   Exporters' dependence on the international coarse grain market is variable. Thailand exports virtually all of its coarse grain

Table 2.1. World grain[a] production and trade, 1960/61 - 1980/81[b]

June-July Trade Years	Coarse Grain			Total Grains		
	Production	Trade	Area Harvested	Yield	Production	Trade
	(mmt)	(mmt)	(mil ha)	(mt/ha)	(mmt)	(mmt)
1960-61	448.1	24.0	278.3	1.61	845	73
1966-67	522.0	40.0	270.3	1.93	1,004	104
1971-72	629.6	49.0	280.9	2.23	1,193	110
1976-77	704.4	82.5	300.1	2.34	1,360	156
1978-79	753.3	90.2	299.7	2.51	1,460	174
1979-80	741.4	100.9	291.9	2.54	1,418	200
1980-81	730.1	105.7	282.9	2.58	1,435	212

[a]Includes coarse grain, wheat and rice.

[b]Source: U.S. Department of Agriculture, Foreign Agricultural Service, Foreign Agricultural Circular Grains, FG 1-82, Jan. 20, 1982; FG 22-82, July 16, 1982; FG 18-78, Nov. 13, 1978; FG 12-73, Oct. 26, 1973.

production. Australia, Argentina, and South Africa export in the neighborhood of 50% of their production, while Canada exports less than 20% of its production. The portion of U.S. production exported has steadily increased to over 25% (Table 2.2). The domestic market in the United States, however, remains the primary production outlet.

On the import side, the dependence of the EEC on the world markets for coarse grain supplies has declined to less than 20% of their consumption in most years. Japan is almost completely dependent on imports. When all importing developed nations are considered, a fairly stable level of 25% of consumption imported is evident. The USSR has become a significant net importer, and Eastern Europe's dependence on international supplies has increased to over 10% of their consumption. Coarse grain exports to LDCs are imported mainly by the rapidly developing nations (LDCR), i.e., OPEC and NONOPEC regions. The dependence of LDCR on the international market is steadily growing (see Table 2.2).

<u>Exports and export market shares</u> The market share data reveal the degree of concentration of grain-exporting countries. The data show that most of the coarse grain exports are under the control of only one country, the U.S. This emphasizes the dominant role of the U.S. as discussed earlier.

Table 2.2. Degree of dependence of international coarse grain market, 1960-1980[a]

	Exporters			Importers					
	Net Exports as Percent of Production			Net Imports as Percent of Total Consumption					
Year	USA	Exporter-4[b]	Exporter-6[b]	EEC9	Japan	DC[c]	USSR	Eastern Europe	LDCR[c]
1960	7.6	9.3	10.3	23.4	43.2	23.5	-3.4[d]	-.4	1.8
1961	11.6	13.5	15.0	28.5	52.1	27.2	-5.7	3.3	1.8
1962	11.6	12.7	14.4	28.7	58.0	30.0	-4.6	3.8	1.3
1963	11.7	13.9	14.7	25.3	83.6	28.8	-4.0	5.0	1.1
1964	15.7	16.8	17.1	24.5	78.5	28.5	-3.0	2.8	-3.6
1965	17.6	19.0	19.2	29.1	78.8	33.6	-4.2	6.2	-4.0
1966	13.7	14.9	16.4	25.8	84.7	32.7	-1.0	0.6	-3.7
1967	12.5	13.8	15.5	23.6	87.5	30.1	-1.0	0.9	-4.2
1968	9.7	12.0	12.4	19.0	88.5	26.7	-1.0	2.6	-1.0
1969	11.5	14.5	15.2	17.5	93.5	27.0	-1.4	3.2	-0.8
1970	12.4	18.3	19.7	23.5	94.6	31.0	-1.1	6.1	1.5
1971	12.6	15.0	16.7	17.1	91.1	25.3	4.6	8.9	6.1
1972	21.0	23.0	22.9	17.2	100.8	27.6	8.6	3.8	12.7
1973	21.6	23.2	23.4	17.3	102.2	26.9	5.5	4.3	9.0
1974	23.5	25.1	26.3	19.0	98.5	26.1	1.8	9.2	12.5
1975	26.8	29.2	29.5	18.4	95.8	25.8	18.7	10.1	11.2
1976	25.9	28.2	28.7	30.7	101.2	35.2	3.3	11.6	14.3
1977	27.5	29.2	29.3	14.3	101.2	26.8	10.1	11.0	22.6
1978	27.5	30.0	30.7	12.4	100.1	25.6	8.1	16.8	22.6
1979	29.9	33.5	33.1	12.1	100.3	25.2	18.8	15.9	21.7
1980	35.0	39.9	40.0	12.9	100.4	25.9	18.6	17.3	23.4

[a]Source: Schmitz et al., 1981, p. 66.

[b]Exporter-4 includes U.S.A., Argentina, Canada, and Australia; Exporter-6 includes South Africa and Thailand in addition to the above four exporters.

[c]DC and LDCR stand for developed regions and rapidly developing nations, respectively.

[d]A minus sign (-) indicates net exports.

Table 2.3 shows the actual coarse grain exports as well as the market shares of the United States, the four largest and the six largest coarse grain exporters.[1] Trade in coarse grain quadrupled over the twenty-one year period of 1960-1980. The United States increased its dominance of the market as indicated by the increase in its export market share from 40 to 60%. None of the other exporters' shares of exports approached that of the U.S. In order of descending importance, they include Argentina, Canada, Australia, South Africa, and Thailand. The first three account for between 15 to 20 percent of the market, and the remaining account for about 6 percent of the market. The four largest exporters account for about 75 percent of the market, while the six largest account for over 80 percent. Particularly important, though, is the growing dominance of the United States, a fact significant enough to help explain the residual supplier behavior of the U.S. in the international coarse grain market.

Importers and import market shares   Table 2.4 indicates that imports have increased rapidly over the last two decades. Almost all increases in DC imports took place in the

[1]The term "the four largest" refers to the U.S., Argentina, Canada, and Australia which is labeled as Exporter-4. The six largest exporters are Exporter-4, South Africa and Thailand, labeled as Exporter-6.

Table 2.3. Actual coarse grain exports and exporters market share, 1960-80[a]

	Actual Exports (million metric tons)							Market Shares (Percent)		
Year	Total Gross Exports	USA	Canada	Australia	Argentina	Thailand	South Africa	USA	Exporters-4	Exporters-6
1960	26.1	11.2	1.0	1.3	2.6	0.5	1.7	42.9	61.7	70.1
1961	33.8	15.2	1.0	0.8	3.9	0.6	2.6	45.0	61.8	71.3
1962	32.6	15.2	0.9	0.6	3.3	0.7	2.8	46.7	61.5	72.3
1963	36.1	16.6	1.3	0.6	5.2	0.9	1.2	46.0	65.6	71.5
1964	37.9	19.6	1.1	0.7	3.7	0.9	0.7	51.7	66.2	70.4
1965	47.4	25.7	1.2	0.7	5.5	1.2	0.5	54.2	69.8	73.4
1966	43.1	20.1	1.3	0.7	4.8	1.3	3.0	46.6	64.0	74.0
1967	44.5	20.7	1.0	0.5	4.7	1.3	2.9	46.5	60.4	69.9
1968	39.7	16.3	0.6	0.9	5.5	1.3	0.8	41.0	58.7	64.0
1969	47.1	18.9	1.7	1.2	7.4	1.6	1.2	40.1	62.0	67.9
1970	53.4	18.6	4.3	2.9	8.8	1.7	2.9	34.8	64.8	73.4
1971	55.5	24.1	4.9	2.8	2.7	2.2	3.7	43.4	62.1	72.8
1972	69.0	38.7	3.9	1.4	7.9	1.1	0.2	56.1	75.2	77.1
1973	81.1	40.7	2.7	2.5	9.1	2.3	3.4	51.9	69.1	77.2
1974	69.2	35.9	3.2	2.8	5.9	2.2	3.4	51.9	69.1	77.2
1975	88.2	50.0	5.0	3.6	6.9	2.6	1.5	56.7	74.3	78.9
1976	88.5	50.6	4.4	2.7	9.6	2.3	2.6	37.2	76.1	81.2
1977	95.0	56.2	4.0	1.6	10.9	1.3	3.4	59.1	76.5	81.4
1978	99.4	60.2	3.9	4.0	9.5	2.2	2.4	60.1	78.1	82.7
1979	100.2	62.1	3.9	3.0	11.6	4.9	2.9	61.9	80.4	88.2
1980	104.1	71.1	4.9	4.4	6.9	5.0	2.9	68.3	83.8	91.4

[a]Source: See Table 2.2.

Table 2.4. Actual coarse grain imports (million metric tons) and market shares, 1960-80[a]

Year	EEC9	Japan	Other Western Europe	DC[b]	USSR	Eastern Europe	China	CP[c]	OPEC	NONOPEC	LDCM[d]	World Imports	Import Shares DC	Import Shares CP	Import Shares LDC
1960	14.4	1.9	2.2	18.9	0.2	1.7	0.7	2.5	0.6	1.0	1.6	23.8	79.4	10.5	6.7
1961	18.3	2.4	2.0	23.1	0.0	2.9	1.2	4.1	0.8	1.9	2.7	30.9	74.8	13.3	8.7
1962	18.3	2.9	3.3	24.9	0.0	2.9	0.4	3.3	1.3	1.4	2.7	31.6	78.8	10.4	8.5
1963	19.1	4.6	3.8	28.9	0.1	3.8	0.8	4.7	0.7	1.7	2.4	35.8	78.2	13.1	6.7
1964	19.1	5.1	3.7	28.4	0.0	2.6	0.3	2.9	0.8	1.3	2.1	34.3	82.8	8.4	6.1
1965	23.4	5.2	5.6	34.6	0.0	3.9	0.1	3.9	0.5	2.7	3.2	42.8	80.8	9.1	7.5
1966	22.2	7.2	5.8	35.8	0.2	2.0	0.1	2.2	0.6	3.8	4.4	43.2	82.9	5.1	10.2
1967	21.7	7.7	5.1	35.2	0.4	2.5	0.1	2.9	1.1	0.1	4.2	43.3	81.3	6.7	9.7
1968	19.8	8.5	4.7	33.6	0.5	2.7	0.0	3.2	1.5	1.5	3.0	41.3	81.4	7.7	7.3
1969	20.1	10.1	4.7	35.6	0.1	2.9	0.0	3.0	2.2	2.0	4.2	43.7	81.5	6.9	9.6
1970	24.1	10.5	5.0	40.3	0.3	3.6	0.0	3.9	2.3	2.0	4.3	49.9	82.2	8.0	8.8
1971	22.7	10.3	5.0	38.8	4.3	5.9	0.4	10.6	3.5	2.1	5.6	57.7	69.7	19.0	10.1
1972	23.2	12.0	6.1	42.2	6.9	4.2	0.9	12.1	5.8	3.3	9.1	64.8	65.1	18.7	14.0
1973	26.8	14.1	8.5	50.4	6.5	5.1	2.1	13.7	5.5	4.6	10.1	75.9	66.4	18.0	13.3
1974	25.0	13.1	8.4	47.6	2.7	6.6	0.5	9.8	6.9	3.6	10.5	69.5	68.5	14.1	15.1
1975	25.9	13.5	7.7	48.2	15.6	8.8	0.0	24.3	7.1	3.8	10.9	84.7	56.9	28.7	12.9
1976	31.7	15.8	8.8	57.5	5.7	8.9	0.0	14.6	9.0	3.9	12.9	86.1	66.8	17.0	15.0
1977	23.8	16.9	10.2	52.0	11.7	8.7	0.1	20.4	12.2	4.6	16.8	90.0	57.9	22.6	18.6
1978	23.8	17.8	9.3	51.2	10.0	10.9	3.1	23.9	13.4	4.6	10.0	94.1	54.4	25.4	19.1
1979	21.3	17.9	13.6	52.9	18.4	11.4	2.0	31.8	13.5	4.2	9.8	95.8	55.2	33.2	20.2
1980	19.5	18.9	12.2	50.6	18.0	10.6	0.9	29.5	17.5	5.7	8.3	101.2	51.1	29.2	22.4

[a]Source: See Table 2.2.

[b]Developed regions.

[c]Centrally planned economies.

[d]Moderately developing nations.

1960s. In the 1970s, however, rapid increases in imports occurred in CP and LDC countries. Figure 2.1 illustrates the relative import levels of the DC, CP, and LDC countries. The most rapid increase in coarse grain imports has taken place in Japan, followed by OWE, while imports into the EEC have been more unstable and have exhibited less rapid growth. Figure 2.2 illustrates the relative import levels of the EEC, OWE, and Japan.

Figure 2.3 depicts the rapid rate of CP import growth. Almost all the growth took place during the 1970s. Eastern Europe and the USSR primarily have been responsible for this growth although the imports by these countries have grown sporadically. China is an insignificant force in the coarse grain market.

Similarly, LDC regions imports grew faster during the 1970s than in the 1960s (Figure 2.4). The NONOPEC region was the principal source of the LDC growth in coarse grain imports during the 1970s, particularly those not experiencing foreign exchange problems--South Korea and Taiwan. OPEC imports have also been growing, but at a smaller rate than the LDCMs. The imports to NONOPEC are relatively small and insignificant during the 1960s.

Table 2.4 indicates that because of the reductions in the rate of growth of EEC imports, the DC market share of imports declined to 54% in 1978 (from 79% in 1960). But the DC region remains the most dominant part of the market. The

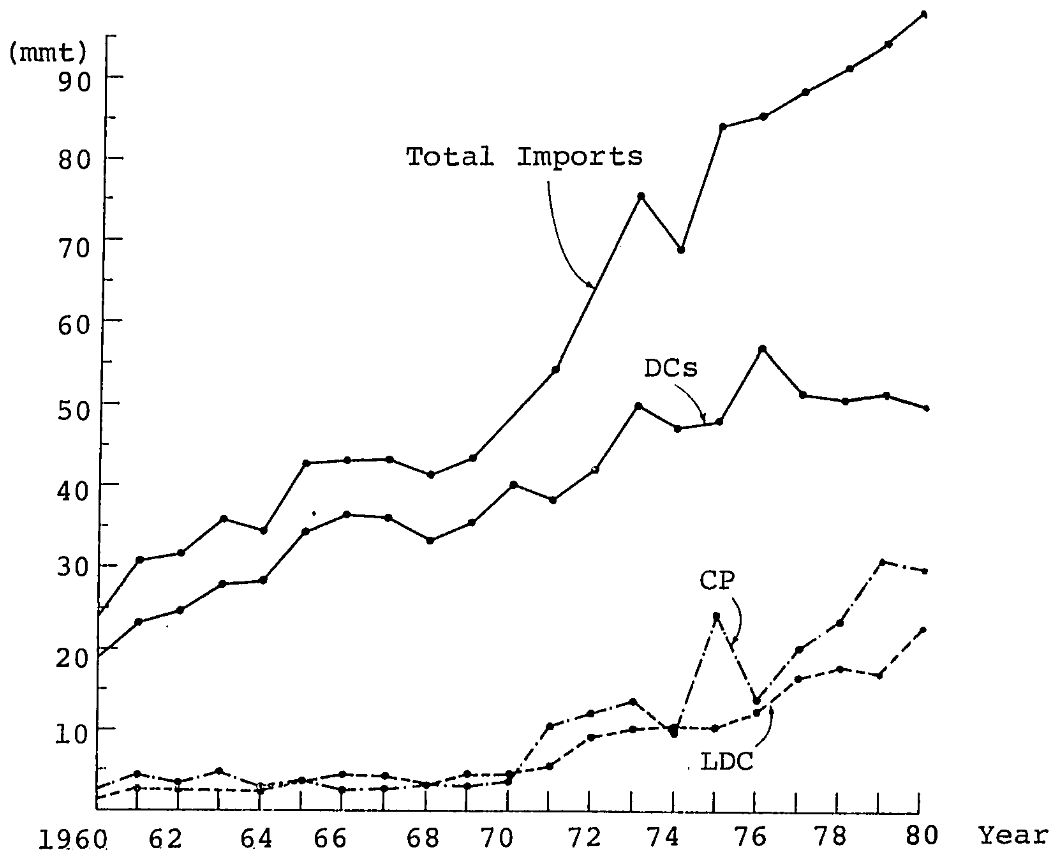

Figure 2.1. Coarse grain imports, 1960-1980 (source: Table 2.2)

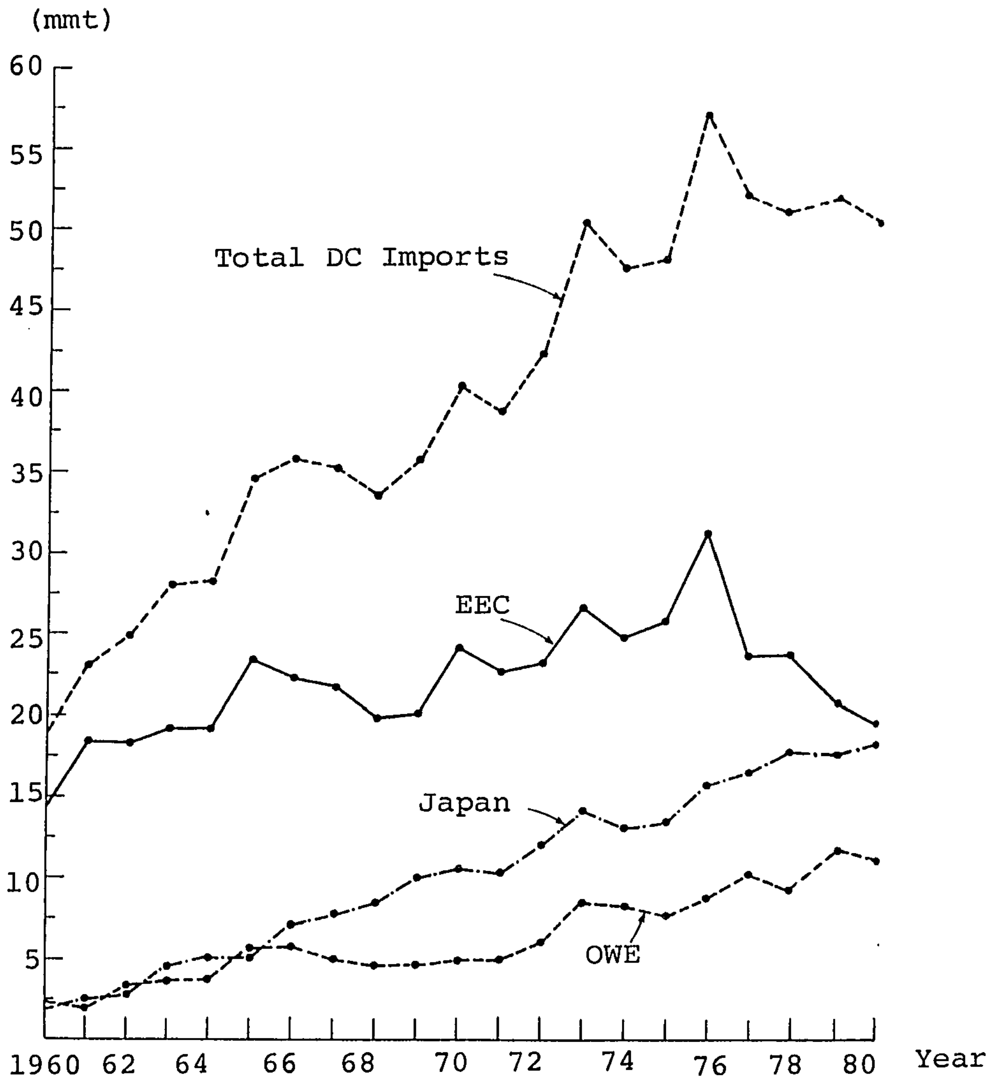

Figure 2.2. Coarse grain imports, developed countries, 1960-1980 (see Table 2.2)

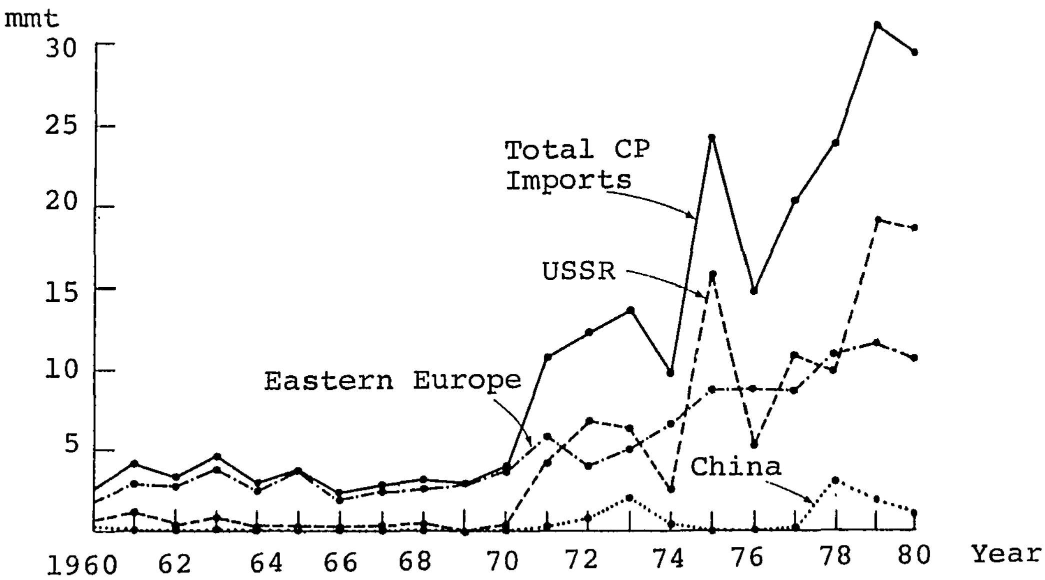

Figure 2.3. Coarse grain imports, centrally planned countries, 1960-1980 (see Table 2.2)

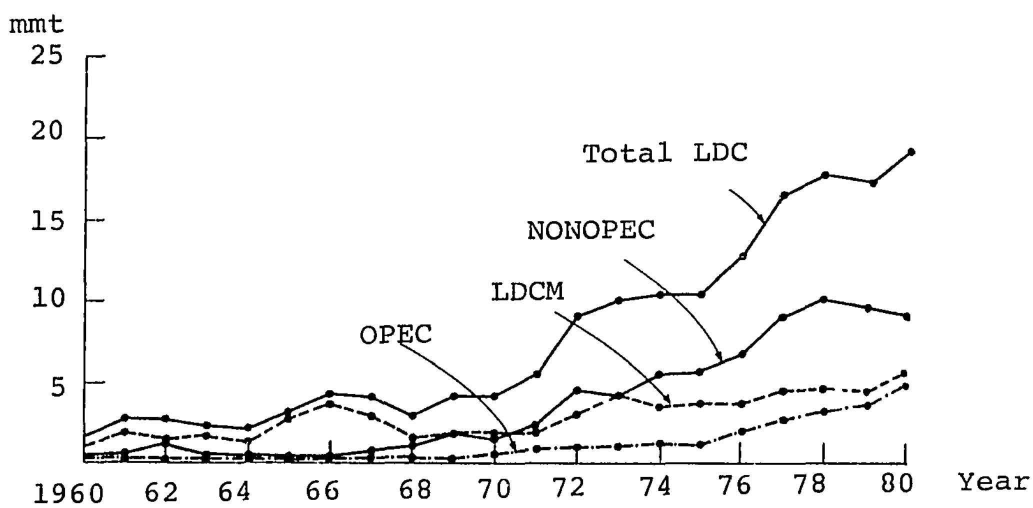

Figure 2.4. Coarse grain imports, LDCs, 1960-1980 (see Table 2.2)

CP market share has risen since 1966 to almost a quarter of the market. The LDC regions' market share has also increased to over 15%. The quantitative characteristics above use gross data figures. In this sense, it double counts regions that both export and import. However, in the coarse grain market these differences are rather small (see Table 2.5), leading to the same conclusions as from using gross figures.

Historical regional policies and their implications

Agricultural policies explain much of the recent behavior of the international coarse grain market. Some regions have effectively isolated themselves from the world market through their policies. An historical description of the regions policies together with the information in the previous section will help to identify the sources of market behavior and instability.

United States   Paarlberg (1980) and Cochrane (1979) indicate that U.S. domestic coarse grain policies have emphasized farm income maintenance and price stability. Furthermore, they indicate that the policy instruments used to achieve this goal have included stock acquisition and voluntary acreage controls. McCalla (1967) suggests that while stock policy influenced the price in any given year, the area control programs in conjunction with income payments were the major influence over time on prices. The Commodity Credit

Table 2.5. Net exports and imports by region-coarse grain, 1960-1980 (million metric tons)[a]

Year	USA	Exporters-6	DC[b] Importers	EEC[c]	Japan	CP[d]	USSR	Eastern Europe	LDC[e]	LDCR[f]	LDCM[g]
1960	10.8	17.0	-14.4[h]	-11.8	-1.9	0.9	1.8	-0.6	0.3	-0.5	0.8
1961	14.8	22.9	-16.6	-15.0	-2.4	0.6	3.0	-1.3	-1.0	-0.5	-0.5
1962	15.1	22.7	-19.1	-15.6	-2.9	0.7	2.5	-1.5	0.1	-0.4	0.5
1963	16.4	25.0	-22.1	-14.8	-4.6	-0.9	1.9	-1.7	0.3	-0.3	0.6
1964	19.2	25.7	-22.8	-14.4	-5.1	0.3	1.6	-1.9	1.7	1.1	0.6
1965	25.4	33.9	-28.3	-17.8	-5.2	-0.3	2.2	-1.7	1.0	1.3	0.3
1966	19.8	30.4	-26.2	-16.0	-7.2	0.4	0.6	-0.3	-0.5	1.2	1.7
1967	20.4	30.1	-25.5	-15.6	-7.7	0.1	0.6	-0.4	0.8	1.4	0.6
1968	16.0	23.9	-24.8	-12.1	-8.5	-0.6	0.6	-0.8	1.5	0.4	1.1
1969	18.6	31.1	-25.1	-11.5	-10.0	-0.5	1.0	-1.6	-0.8	0.3	0.5
1970	18.2	38.6	-28.2	-15.6	-10.5	-2.0	0.8	-2.9	-0.3	-0.6	0.3
1971	23.8	40.0	-23.1	-11.9	-10.3	-8.7	-3.4	-4.9	-2.1	-2.6	0.5
1972	38.3	51.9	-30.0	-12.3	-12.0	-9.7	-6.6	-2.2	-1.1	-5.3	-0.8
1973	40.4	6.6	-32.8	-13.0	-14.1	-10.0	-6.0	-2.4	-5.1	-3.9	-1.2
1974	35.4	51.9	-32.3	-13.9	-13.1	-7.8	-1.7	-5.6	-6.6	-5.7	-0.9
1975	49.6	68.5	-33.7	-13.5	-13.5	-21.8	-15.5	-6.4	-5.7	-5.6	0.1
1976	50.3	71.2	-44.7	-22.2	-15.8	-11.1	-3.7	-7.4	-8.1	-7.6	-0.5
1977	56.0	76.3	-34.8	-10.4	-16.9	-13.8	-10.7	-7.0	-14.4	-12.2	-2.4
1978	59.9	81.2	-34.5	-9.7	-17.8	-21.7	-8.9	-9.7	-15.5	-13.7	-1.8
1979	71.3	96.9	-35.7	-8.1	-17.1	-29.3	-18.4	-9.9	-15.2	-13.5	-1.7
1980	69.3	99.6	-34.4	-6.0	-18.2	-26.8	-18.0	-8.7	-16.3	-13.9	-2.4

[a]Source (see Table 2.2).

[b]Developed countries.

[c]Original nine members of the European Economic Community.

[d]Centrally Planned Nations.

[e]Developing Nations.

[f]Rapidly Developing Nations (OPEC and NONOPEC regions).

[g]Moderately Developing Nations.

[h]Minus sign indicates net importers.

Corporation (CCC) manages the government coarse grain stock policy. Until 1977, the disposal price of CCC stocks served as a price ceiling as long as stocks were held, while the nonrecourse loan program provided a domestic price floor. The 1977 Agricultural Act significantly increased the gap between the loan rate and the CCC stock-release price.

The U.S. as the dominant market supplier essentially has maintained world prices between the CCC stock-release price and the nonrecourse loan rate. Furthermore, with greater price instability under the flexible exchange rate system, the task of managing the world price has become more difficult. In fact, U.S. domestic price policy took the price corridor approach starting with the 1973 farm legislation, the year of the shift to a system of floating rates (Schuh, 1979).

Argentina The Argentine government has intervened extensively in its coarse grain market. Prior to the 1976 military government, the domestic price was kept under the world price (or their export price). This difference was made up by two types of taxes: a purpose and a retention tax. The purpose tax was used to generate revenues to cover the operating expenses of the National Grain Board. The retention tax was used to fill up the remaining differentials between domestic and foreign prices. Mielke (1977) suggests that the military government abandoned the cheap pricing policy in an attempt to liberalize trade. However, retention of some export taxes and application of selective devaluation of the peso--used to control foreign exchange earnings--suggest that the internal prices are still somewhat isolated from the world market prices, although to a lesser extent than before 1976.

Canada[1] The Canadian Wheat Board (CWB) is the sole exporting agency for Canadian coarse grain. Since 1935, the CWB has also been the major domestic marketing agency for grains in general.

The Canadian government supports a minimum producer price by establishing initial producer payments. The payments are defined on the basis of anticipated market opportunities and become guaranteed minimum prices. After all grains are marketed and the CWB's expenses are deducted, the proceeds are distributed to producers as final payments based upon the grades and qualities of grain delivered. If net returns are insufficient to cover the initial payments, the deficit is made up by the government. A producer can deliver a quantity of a particular grain to the CWB according to the amount of land allocated to it. In 1973, the role of the CWB as the sole marketer of domestic coarse grain was extended to the

[1]This review benefits from two studies by Bray (1978) and Shiau and Myers (1982).

private grain trade. The CWB "market price" was determined outside the market, while the nonboard market price was market determined. In August 1976, the CWB began to offer coarse grain for sale in Eastern Canada at a price competitive with U.S. corn. Although coarse grain can still be purchased through the nonboard market, CWB prices, in effect, became ceiling prices, reflecting a change in the competitive position of U.S. corn in the eastern Canadian market.

Australia[1] The typical method of marketing coarse grain in Australia is through statutory marketing boards which have sole authority for buying, handling, and selling of a grain in a particular region. This is the basic system for most of the barley and sorghum in Australia. Oats are still sold via the private trade or through voluntary pools.

Barley growers have the option to either sell their grain to their boards or to buyers in other states. The sorghum market is controlled by two boards: Central Queensland Grain Sorghum Marketing Board (CQGSMB) and New South Wales Grain Sorghum Marketing Board (NSWGSMB). Since 1969/70, Australia has, on the average, exported 80% of its sorghum production, all of which has been controlled by the two marketing boards.

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[1]The review here benefited from Richards (1980).

Spriggs (1978) reports that domestic barley prices in Australia tend to move with export prices. This is partly due to the exception that allows growers to legally sell their grain to individuals in another state, and partly to competition from oats, which are handled totally by private entities. He indicates that, although the domestic barley price is set in each state by the particular board operating there, domestic barley prices have been highly correlated with export prices.

Because of large Australian sorghum exports (relative to production), the domestic selling price of sorghum moves closely with world prices. The rapid rise in production and exports since 1969 has turned sorghum into an export-oriented crop, and the domestic price has become determined largely outside of Australia.

South Africa[1] Production and exports of corn--the primary South African coarse grain--are completely controlled by the South African Maize Board. The board sets consumer and producer prices and has been obligated to purchase all production. Exports have been handled on a tender basis. Japan, the United Kingdom, and Taiwan are major markets. The Board generally acquires inventories based on traditional consumption

[1]See Bredahl and Green (1983) for more details.

patterns and exports the remaining supplies. Witucki (1976) found that variations in exports came about more as a function of the weather than as a response to economic conditions. Therefore, variation in export levels primarily reflects variations in supply.

Thailand Konjing (1977) reported that a large portion of Thai coarse grain exports (about 70%) has been covered by long-term agreements with importing countries. Recent agreements have not established the price. Export prices have been based on the Chicago cash or futures price of U.S. no. 2 yellow corn. Konjing suggests that export supplies have been affected by production, which, in turn, were affected by the world price transmission mechanism.

European Economic Community The Common Agricultural Policy (CAP) of the EEC effectively isolates the domestic grain prices of the region from the world market. As many authors have indicated, this makes the import demand perfectly inelastic with respect to world price (e.g., Rastegari (1982), Zwart and Meilke (1979) and Abbott (1979a). The objective of the CAP is to protect the EEC domestic markets from nonmember country exports and to reduce food dependency. The main features of CAP have been the removal of all restrictions on member countries' trade of commodities, uniform support prices for agricultural products among members, and the imposition of a common system of tariffs with respect to third countries. The import grain prices are bound to a minimum level called "threshold price". Its purpose is to assure that grain imported from nonmember countries sells at or above the EEC "target price". The "target price" is fixed at the level which is hoped producers achieve on the open market in the community where grain is in short supply.

Japan   Barley imports are handled by the Japanese government. The practice has been to purchase barley at world prices and resell it at much higher prices. Japan's coarse grain imports, however, are corn dominated, which is free of governmental policy intervention. Japan's extreme dependence on the international coarse grain market (100 percent of consumption), indicates Japan's importance in the world coarse grain market. Clearly, Japan's domestic and trading policies have allowed the world price to affect its internal markets.

Other Western Europe[1]   Most countries in Western Europe outside the EEC (OWE) utilize state trading corporations to purchase coarse grain. In addition, many of the

[1]See Bredahl and Green (1983) for more detail.

OWE countries pursue low and subsidized domestic food programs. In view of these policies, the import demand elasticity is likely very low.

<u>USSR</u> Schmitz et al. (1981) indicate that the USSR appears to have decided to maintain domestic coarse grain consumption levels despite extreme variations in domestic production. They indicate that because of rising real incomes combined with stable prices, consumers have increased the demand for meat. Having decided on its import needs, the country state-trades and tends to bargain on prices.

Because of these reasons, the price elasticity of USSR import demand is likely very small. On the other hand, a CIA (1979) report predicts that the USSR will have foreign exchange problems in the 1980s. With the USSR's growing import quantities and exchange shortages, one may expect to see more price response.

Schmitz et al. (1981) report that the bulk of the USSR foreign exchange is made up of gold; in addition, the USSR is a large gold exporter. Therefore, so long as gold prices increase more rapidly than grain prices, the cost of importing grains to the USSR will decrease.

Eastern Europe   Except for Yugoslavia, all other members of this region have historically shown very small adjustments to world price movements. Their imports reflect the national priority of increased meat production and inadequate domestic coarse grain supplies to meet that goal. Their increased consumption is due to the fact that their real incomes have doubled since 1966, while their domestic nominal prices have remained constant by political necessity (Schmitz et al., 1981).

Less developing regions   In general, the LDC countries are characterized by rapidly growing populations, rising incomes, and less rapidly growing and unstable agricultural production. Domestic policies that maintain low urban food prices and the lack of resources to increase producer prices have increased their dependence on external food sources. Foreign exchange availability, therefore, appears to be the major limiting factors on grain purchases.

The OPEC region, however, does not suffer from foreign exchange limitations. In fact, one can anticipate that the food demand could soon become saturated. However, rising per capita incomes are increasing the demand for meat. To the extent that meat production can be expanded, demand for coarse grain should increase. Because of relatively high income levels, these countries import meat rather than feedstuffs.

The remaining LDCs are commonly characterized by poverty and extreme foreign exchange limitations. Coarse grain is a commodity used by affluent nations that can afford the high cost of producing meat. Among all the limiting factors in meat production, the low urban food price policy generally practiced by these nations is known as the most important. Because of cheap food policies--perhaps due to political necessity--there has not been a connection between the domestic and world prices in these countries.

CHAPTER III. METHODOLOGY

This chapter discusses the world grain trade model used in this study in both conceptual and mathematical terms. The graphic representation indicates the model type, its advantages, and limitations. The mathematical conceptual model describes the theoretical foundation, variable specifications, and expected signs of the variables in each equation.

Conceptual Analysis

The coarse grain trade model used is a multi-country nonspatial equilibrium type (Thompson, 1981). To incorporate the world market influence on U.S. agricultural markets, many studies attach an aggregate export demand from the rest of the world as an additional sector. These models are known as two-region models. One region is composed of the behavioral equations depicting the domestic market of the country of interest, and the other explains the country's net trade in the particular commodity of interest. Two-region models assume that the behavioral responses to changing world market conditions are identical. However, different countries permit different rates of adjustments in their domestic markets in response to changes in world market conditions. The two-region model, therefore, can only be used to analyze the domestic and foreign trade policies of a particular country. A measurement of the effect of exogenous world market shocks on that country's world export or import share is not possible.

A multi-regional nonspatial model, however, consists of internal and external sectors of all importing and exporting regions. All trading regions are then linked together through the world balance of total supply and demand, determined simultaneously with the world price. A multi-regional nonspatial model can be used to conduct various policy impact analyses to measure the resulting effects on world trade and on the markets of all trading countries. The model allows for domestic price differences due to policy factors and transportation costs.

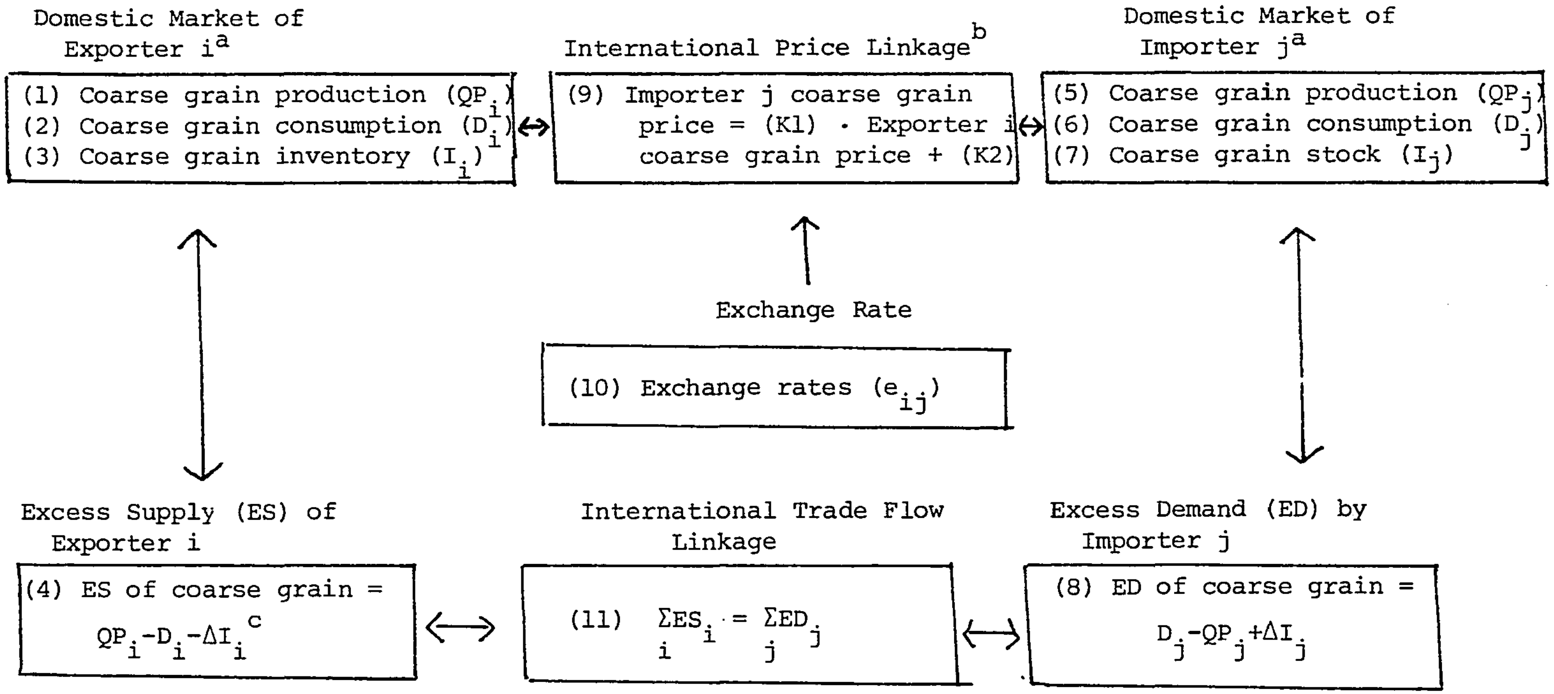
Nonspatial models assume homogeneity of the trading product in terms of physical characteristics and country of origin, and consider only net trade flow of each region. In this respect, nonspatial models are limited in their capacity to consider regional trade flows and market shares analysis. Nevertheless, nonspatial models provide the necessary components to address the question of interest in this research.

The coarse grain trade model to be used in this model will be composed of three country categories: exporting countries, importing countries, and a world market clearing sector. The domestic and trade sectors of all trading regions are linked through the world trade clearance equation and price linkage equations of coarse grain. The general structure of the model is illustrated graphically in Figure 3.1 (Williams, 1981, p. 271).

The domestic markets of any exporting country i is represented by relationships (1)-(3). Similarly, the domestic market of any importing country is explained by relationships (5)-(7). These relationships represent the coarse grain production, demand, and stock response of any exporting or importing country to changes in variables such as prices. Equations (4) and (8) are, respectively, an exporting country's excess supply and an importing country's excess demand identities. These are international trade equations for exporting and importing countries which link the internal and external sectors of each region.

Equation (9) represents the coarse grain price linkages between the exporting and importing regions in the model. K1 and K2 represent policy factors and transportation costs, adjusted to local currency for coarse grain that cause these regional prices to diverge.

Equation (11) is the international trade flow linkage. World trade and all domestic sectors of all regions are linked through these trade identities. Through these identities,



[a]i = any exporter, i=1,...,n; and j = any importer, j=1,...,m.

[b]The K1 and K2 include exchange rate, and valorem taxes (subsidies), specific tax (subsidy), and transportation costs.

[c]Should be read "change in".

Figure 3.1. Schematic representation of the conceptual model of the world coarse grain market (adapted from Williams, 1981)

and the price linkage equations, regional trade volumes, domestic supplies, domestic disappearances, and coarse grain prices are determined for each region.

Finally, Equation (10) is added to endogenize exchange rates as a function of money supplies, real incomes, and interest rates. In the structural model used in this study, Equation (10) accounts for the impact of U.S. monetary policy on the value of the U.S. dollar world prices, the quantity traded, production, and domestic disappearance.

To reduce the size of the model, all regional components of the model, except the U.S., are expressed in reduced form. For example, for a given importer j, Equations (5-7) are substituted into (8) to express the country's net imports as a function of domestic price and all other variables on the right hand sides of Equations (5-7). The essential feature of the net export or import demand functions is that they reflect the behavior of the respective exporting or importing countries in the world market as perceived by the other trading countries. Owing to quantitative restrictions on trade or the nature of the trade decision-making process, prices may not have an effect on the quantity traded. That is, for selected countries, export supply or import demand might be exogenously determined, without regard for world market price.

Mathematical Representation

A general concept behind each equation in this trade model is described in Table 3.1 with the variable definitions in Table 3.2. The expected signs are indicated above each variable in parentheses.

The United States coarse grain production (1) is determined by yield times acreage harvested. Yields are assumed to be exogenous, while acreage harvested (2) is a function of acreage planted. An appropriate acreage response function (3) has received attention in the literature since government programs usually require planting within guidelines. Consequently, realistic analyses of acreage response must account for government influence as well as the market. Programs such as guaranteed minimum prices on production, payment for diverting land out of production, and set aside as prerequisites for access to loans are the common forms of acreage control.

Houck et al. (1976) analyzed the impact of various government programs on crop acreage response functions. In this study, the "effective support and diversion payment rate" method and market prices are used to include both government and market attractiveness. Effective rates are the product of announced nominal payment rates on planted acreage and the proportion of base acreage eligible for

Table 3.1. General model of world coarse grain market

$$(1)\quad QP1_t \equiv YLD1_t \cdot AH1_t$$

$$(2)\quad AH1_t = f(\overset{(+)}{AP1_t})$$

$$(3)\quad AP1_t = f\left(AP1_{t-1}, \overset{(+)}{\frac{CWP1_{t-1}}{IPPF1_{t-1}}}, \overset{(+)}{\frac{ESRF_t}{IPPF1_t}}, \overset{(-)}{\frac{EDRF_t}{IPPF1_t}}, \overset{(-)}{\frac{PC_{t-1}}{IPPF1_{t-1}}}, \overset{(-)}{\frac{ESRC_t}{IPPF1_t}}, \overset{(+)}{\frac{EDRC_t}{IPPF1_t}}\right)$$

$$(4)\quad FD1_t = f\left(\overset{(+)}{\frac{PL1_t}{CPI1_t}}, \overset{(+)}{\frac{PL1_{t-1}}{CPI1_{t-1}}}, \overset{(-)}{\frac{CWP1_t}{CPI1_t}}, \overset{(-)}{\frac{CWP1_{t-1}}{CPI1_{t-1}}}, \overset{(+)}{\frac{WPSOM1_t}{CPI1_t}}, \overset{(+)}{\frac{WPSOM1_{t-1}}{CPI1_{t-1}}}, \overset{(+)}{GCAU1_t}\right)$$

$$(5)\quad NFD1_t = f\left(\overset{(-)}{\frac{CWP1_t}{WPIX1_t}}, \overset{(+)}{\frac{PS_t}{WPIX1_t}}, \overset{(+)}{\frac{GNP1_t}{WPIX1_t}}\right)$$

$$(6)\quad EI1_t = f\left(\overset{(+)}{QP1_t}, \overset{(-)}{\frac{CPW1_t}{CPI1_t}}, \overset{(+)}{BI1_t}\right)$$

$$(7)\quad E8US_t = f(\overset{(-)}{MS1}, \overset{(+)}{RDY1}, \overset{(-)}{DR1}, \overset{(+)}{MS8}, \overset{(-)}{RDY8}, \overset{(+)}{DR8})$$

$$(8)\quad NMT8_t = f\left(\overset{(-)}{\frac{WPCRN8_t}{WPI8_t}}, \overset{(+)}{\frac{WPSOM8_t}{WPI8_t}}, \overset{(-)}{QP8_t}, \overset{(-)}{BI8_t}, \overset{(+)}{\frac{PL8_t}{WPI8_t}}, \overset{(+)}{GCAU8_t}\right)$$

$$(9)\quad WPCRN8_t = K81_t \cdot E8US_t \cdot CWP1_t + K82_t$$

Table 3.1 (Continued)

(10) $NMT10_t = f(\overset{(-)}{PRICE10_t}, \overset{(-)}{QP10_t}, \overset{(-)}{BI10_t}, \overset{(+)}{GCAU10_t})$

(11) $PRICE10 = CWP1_t/PRGOLD78_t$

(12) $NXT2_t = f(\overset{(+)}{\frac{NPRCRN2_t}{WGPIZ_t}}, \overset{(-)}{\frac{WPSOM2_t}{WGPIZ_t}}, \overset{(+)}{QP2_t}, \overset{(+)}{BIZ_t}, \overset{(-)}{\frac{PL2_t}{WGPI2_t}}, \overset{(-)}{GCAU2_t})$

(13) $NPRCRN2_t = K21_t \cdot E2JA_t \cdot WPCRN8_t + K22_t$

(14) $NXT3_t = f(\overset{(+)}{\frac{BARWP3_t}{DEF3_t}}, \overset{(-)}{\frac{WPSOM3_t}{DEF3_t}}, \overset{(+)}{QP3_t}, \overset{(+)}{BI3_t}, \overset{(-)}{\frac{PL3_t}{DEF3_t}}, \overset{(-)}{GCAU3_t})$

(15) $BARWP3_t = K31_t \cdot E3JA_t \cdot WPCRN8_t + K32_t$

(16) $NXT4_t = f(\overset{(+)}{\frac{CGP4_t}{DEF4_t}}, \overset{(-)}{\frac{WPSOM4_t}{DEF4_t}}, \overset{(+)}{QP4_t}, \overset{(+)}{BI4_t}, \overset{(-)}{\frac{PL4_t}{DEF4_t}}, \overset{(-)}{GCAU4_t})$

(17) $CGP4_t = K41_t \cdot E4JA_t \cdot WPCRN8 + K4t_2$

Table 3.1 (Continued)

$$(18)\quad \mathrm{NXT5}_t = f\left(\overset{(+)}{\frac{\mathrm{WPCRN5}_t}{\mathrm{CPI5}_t}}, \overset{(-)}{\frac{\mathrm{WPSOM5}_t}{\mathrm{CPI5}_t}}, \overset{(+)}{\mathrm{QP5}_t}, \overset{(+)}{\mathrm{BI5}_t}, \overset{(-)}{\frac{\mathrm{PL5}_t}{\mathrm{CPI5}_t}}, \overset{(-)}{\mathrm{GCAU5}_t}\right)$$

$$(19)\quad \mathrm{WPCRN5}_t = \mathrm{K51}_t \cdot \mathrm{E5JA}_t \cdot \mathrm{WPCRN8}_t + \mathrm{K52}_t$$

$$(20)\quad \mathrm{NXT6}_t = f\left(\overset{(+)}{\frac{\mathrm{EXPRCRN6}_t}{\mathrm{CPI6}_t}}, \overset{(-)}{\frac{\mathrm{WPSOM6}_t}{\mathrm{CPI6}_t}}, \overset{(+)}{\mathrm{QP6}_t}, \overset{(+)}{\mathrm{BI6}_t}, \overset{(-)}{\frac{\mathrm{PL6}_t}{\mathrm{CPI6}_t}}, \overset{(-)}{\mathrm{GCAU5}_t}\right)$$

$$(21)\quad \mathrm{EXPRCRN6} = \mathrm{K61}_t \cdot \mathrm{ELJA} \cdot \mathrm{WPCRN8} + \mathrm{K62}_t$$

$$(22)\quad \mathrm{SEEDC1}_t = (\mathrm{BI1}_t + \mathrm{QP1}_t) - (\mathrm{NFD1}_t + \mathrm{NXT1}_t + \mathrm{EI1}_t + \mathrm{FD1}_t)$$

$$(23)\quad \mathrm{NXT1}_t = (\mathrm{NMT8}_t + \mathrm{NMT10}_t + \mathrm{NMTREST}_t) - (\mathrm{NXT2}_t + \mathrm{NXT3}_t + \mathrm{NXT4}_t + \mathrm{NXT5}_t + \mathrm{NXT6}_t)$$

Table 3.2. Definitions of variables in general model of world coarse grain market

Endogenous variables

$QP1_t$ = U.S. coarse grain production in period t

$AH1_t$ = U.S. coarse grain acreage harvested in period t

$AP1_t$ = U.S. Coarse grain acreage planted in period t

$CWP1_t$ = U.S. coarse grain price (\$/MT) in period t

$FD1_t$ = U.S. coarse grain feed demand in period t

$NFD1_t$ = U.S. coarse grain food demand in period t

$EI1_t$ = U.S. coarse grain ending inventory demand in period t

$E8US_t$ = Japan-U.S. exchange rate, yen/U.S. $ in period t

$NMT8_t$ = Japan net coarse grain import demand in period t

$WPCRN8_t$ = Japan coarse grain price (yen/MT) in period t

$NMT10_t$ = USSR net coarse grain import demand in period t

$PRICE10_t$ = U.S. goarse grain price in terms of gold (02/MT) in period t

$NXT2_t$ = Argentina net coarse grain exports supply in period t

$NPRCRN2_t$ = Argentina coarse grain price (pesos/MT) in period t

$NXT3_t$ = Canada net coarse grain exports supply in period t

Table 3.2 (Continued)

$BARWP3_t$ = Canada coarse grain price in period t

$NXT4_t$ = Australia net coarse grain exports supply in period t

$CGP4_t$ = Australia coarse grain price (Aus $/MT) in period t

$NXT5_t$ = South Africa net coarse grain export supply in period t

$WPCRN5_t$ = South africa coarse grain price (Rand/MT) in period t

$NXT6_t$ = Thailand net coarse grain export supply in period t

$EXPRCRN6_t$= Thailand coarse grain price (Baht/MT) in period t

$NXT1_t$ = U.S. net coarse grain export supply in period t

<u>Exogenous variables</u>

$YLD1_t$ = U.S. coarse grain yield per hectare in period t

$AP1_{t-1}$ = U.S. coarse grain acreage planted in period t-1

$CWP1_{t-1}$ = U.S. coarse grain price in period t-1

$ESRF_t$ = U.S. coarse grain effective support rate in period t

$EDRF_t$ = U.S. coarse grain effective diversion rate in period t

PC_{t-1} = U.S. coarse grain effective competitor crop price in period t-1

$ESRC_t$ = U.S. coarse grain effective competitor crop support rate in period t

Table 3.2 (Continued)

$EDRC_t$ = U.S. coarse grain effective competitor crop diversion rate in period t

$IPPF1_t$ = Index of prices of all commodities used in U.S. agricultural production in period t

$IPPF1_{t-1}$ = IPPF1 in period t-1

$PL1_t$ = U.S. livestock and product price in period t

$PL1_{t-1}$ = PL1 in period t-1

$WPSOM1_t$ = U.S. soymeal price in period t

$WPSOM1_{t-1}$ = U.S. soymeal price in period t-1

$GCAU1_t$ = Number of U.S. grain consuming animal units in period t

$CPI1_t$ = U.S. consumer price index in period t

$CPI1_{t-1}$ = U.S. consumer price index in period t-1

PS_t = U.S. price index of related goods to coarse grain food demand in period t

$GNP1_t$ = U.S. gross national product in period t

$WPIX1_t$ = U.S. wholesale price index in period t

$BI1_t$ = U.S. beginning coarse grain inventory in period t

$MS1_t$ = U.S. money supply in period t

$RDY1_t$ = U.S. real income in period t

$DR1_t$ = U.S. interest rate in period t

Table 3.2 (Continued)

$MS8_t$ = Japan money supply in period t

$RDY8_t$ = Japan real income in period t

$DR8_t$ = Japan interest rate in period t

$WPSOM8_t$ = Japan price of other major competing noncoarse grain feed in period t

$QP8_t$ = Japan coarse grain rpoduction in period t

$BI8_t$ = Japan beginning coarse grain inventory in period t

$PL8_t$ = Japan livestock and product price in period t

$GCAU8_t$ = Japan number of grain consuming animal units in period t

$WPI8_t$ = Japan wholesale general price index in period t

$K81_t$, $K82_t$ = all factors which differentiate the Japanese and U.S. coarse grain prices in period t

$QP10_t$ = USSR coarse grain production in period t

$BI10_t$ = USSR beginning coarse grain inventory in period t

$PRGOLD78_t$ = Price of gold (US $/oz) in period t

$WPSOM2_t$ = Argentina price of other major competing noncoarse grain feed in period t

$QP2_t$ = Argentina coarse grain product in period t

$BI2_t$ = Argentina beginning coarse grain inventory in period t

$PL2_t$ = Argentina livestock and product price in period t

Table 3.2 (Continued)

$\mathrm{GCAU2}_t$ = Argentina number of grain consuming animal units in period t

$\mathrm{WGPI2}_t$ = Argentina general price index in period t

$\mathrm{E2JA}_t$ = Argentina-Japan exchange rate (pesos/yen) in period t

$\mathrm{K21}_t$, $\mathrm{K22}_t$ = All factors which differentiate the Argentinian and U.S. coarse grain prices in period t

$\mathrm{WPSOM3}_t$ = Canada price of other major competing noncoarse grain feed in period t

$\mathrm{QP3}_t$ = Canada coarse grain production in period t

$\mathrm{BI3}_t$ = Canada beginning coarse grain inventory in period t

$\mathrm{PL3}_t$ = Canada livestock and product price in period t

$\mathrm{GCAU3}_t$ = Canada number of grain consuming animal units in period t

$\mathrm{DEF3}_t$ = Canadian implicit price deflator in period t

$\mathrm{E3JA}_t$ = Canada-Japan exchange rate (Can \$/year) in period t

$\mathrm{K31}_t$, $\mathrm{K32}_t$ = All factors which differentiate the Canadian and U.S. coarse grain prices in period t

$\mathrm{WPSOM4}_t$ = Australia price of other major competing noncoarse grain feed in period t

$\mathrm{QP4}_t$ = Australia coarse grain production in period t

$\mathrm{BI4}_t$ = Australia beginning coarse grain inventory in period t

$\mathrm{PL4}_t$ = Australia livestock and product price in period t

Table 3.2 (Continued)

$GCAU4_t$ = Australia number of grain consuming animal units in period t

$DEF4_t$ = Australian implicit price deflator in period t

$E4JA_t$ = Australia-Japan exchange rate (Aus $/yen) in period t

$K41_t$, $K42_t$ = All factors which differentiate the Australian and U.S. coarse grain prices in period t

$WPSOM5_t$ = South Africa price of other major competing noncoarse grain feed in period t

$QP5_t$ = South Africa coarse grain production in period t

$BI5_t$ = South Africa beginning coarse grain inventory in period t

$PL5_t$ = South Africa livestock and product price in period t

$GCAU5_t$ = South Africa number of grain consuming animal units in period t

$CPI5_t$ = South Africa wholesale general price index in period t

$WPSOM6_t$ = Thailand price of other major competing noncoarse grain feed in period t

$QP6_t$ = Thailand coarse grain production in period t

$BI6_t$ = Thailand beginning coarse grain inventory in period t

$PL6_t$ = Thailand livestock and product price in period t

$GCAU6_t$ = Thailand number of grain consuming animal units in period t

$CPI6_t$ = Thailand consumer price index in period t

Table 3.2 (Continued)

$E6JA_t$ = Thailand-Japan exchange rate (Baht/yen) in period t

$K61_t$, $K62_t$ = All factors which differentiate the Thai and U.S. coarse grain prices in period t

$SEEDC1_t$ = U.S. coarse grain seed consumption in period t

$NMTREST_t$ = Rest of the world net coarse grain imports in period t planting (or required for diversion and set aside). In effect, these variables state the payment rate in terms of the base acreage. Announced payment rates are typically expressed in terms of planted or diverted acreage. Equation (3) in Table 3.1 is based on the result of the Nerlovian distributed lag concept, in which naive price expectation is assumed (Labys, 1973).

The United States coarse grain demands are composed of three parts: feed demand (4), nonfeed demand (5), and ending inventory demand (6).

The feed demand (4) is derived from the demand for livestock and livestock products. The feed demand equation is derived through considering a producer maximizing current and anticipated net revenue in a two period framework. Because of the competitive nature of the market, current prices of livestock and livestock products are given to the producer. However, the anticipated price is formed independently of the producer's production decisions. Furthermore, a production function is assumed to represent the technical relationship between production and inputs.

Decisions to be made in period one are the number of animals to be fed and marketed this period and the next period. Up to some point, the producer can increase the number of stocked and marketed animals. However, after that point, the increase in the number of either will come at the expense of the other. The production function jointly determines the number of grain consuming animal units fed and marketing of livestock and livestock products in each period.

In the current period, the number of grain consuming animal units fed and the marketing of livestock and livestock products are assumed to depend on the amount of coarse grain and other feeds fed in the period and the number of grain consuming animal units fed in the previous period. Also, a similar production function is assumed to be obtained in the next period. In other words, the expansion in the current period is constrained by the number of grain consuming animal units fed in the previous period. This assumption is justified, since the marketing of animals from gestation takes from one-half year to several years for larger animals such as hogs and beef cattle. In fact, the indices for grain consuming animal units currently fed and marketed have larger weights for older and larger animals, which were fed last year. Also, other animals, such as dairy cows and breeding stock, can last many years.

The producer is assumed to maximize the current and anticipated revenue, i.e.,

$$R = [(PL) \cdot L - (PF) \cdot F - (PO) \cdot O] + [(PL_{+1}) \cdot L_{+1} - (PF)_{+1} \cdot F_{+1} - (PO)_{+1} \cdot O_{+1}]$$

subject to both production functions constraints. If the implicit joint production functions can be separated into additive functions of inputs and outputs, then the Langrangian function can be written as:

$$H = R + a[g(AU,L) - f(F,O,AU_{-1})] + b[h(AU_{+1},L_{+1}) - k(F_{+1},O_{+1},AU)]$$

where the variables are defined as follows:

PL = price of livestock and livestock products;

PF = price of coarse grain;

PO = price of other feeds;

AU = number of grain-consuming animal units fed;

L = marketing of livestock and livestock products;

F = quantity of other feeds fed;

a,b = Langrangian multipliers;

O = quantity of other feeds fed;

a,b = Lagrangian multipliers;

g,f,h,k = undefined functional forms.

The subscript +1 indicates anticipated or planned values, while -1 indicates the value of a variable during the previous period.

If the function is well-behaved, so that a constrained maximum is defined by first order conditions, the following deductions can be made:

$$PF\frac{df}{dL} = PL \text{ and,}$$

$$PF\frac{df}{dAU} = PL_{+1}\,\frac{dL_{+1}}{dAU} = -PF_{+1}\,\frac{dF_{+1}}{dAU} = -PO_{+1}\,\frac{dO_{+1}}{dAU}\,.$$

The first of these two expressions says that, in equilibrium, the return from a unit increase in marketing livestock and livestock products equals the cost of coarse grain needed to produce the additional unit. The second of the two expressions states that the marginal coarse grain cost of increase in fed animal units in this period equals the anticipated marginal revenue of selling the additional animal. This is also equal to the marginal savings of the cost of either coarse grain or other feed that would be possible if the current marginal increase in animal units fed were substituted for coarse grain or other feed fed in the next period, leaving the next period's output unchanged.

If the ten first order conditions in ten unknowns are solvable, the coarse grain demand for animal feed can be expressed as:

$$F = F(\overset{(+)}{PL}, \overset{(+)}{PL_{+1}}, \overset{(-)}{PF}, \overset{(-)}{PF_{+1}}, \overset{(+)}{PO}, \overset{(+)}{PO_{+1}}, \overset{(+)}{AU_{-1}}).$$

Under the naive price expectation assumption, and using slightly different notations, the last equation above becomes Equation (4) in the general model in Table 3.1.

The United States nonfeed coarse grain demand by industry is Equation 5 in Table 3.1 and is also a derived demand. This equation can be thought of as a reduced form equation. The nonfeed coarse grain consumption is used to produce food such as baked goods, processed foods, and alcoholic beverages. Assuming perfect competition in output and input markets of this industry, the nonfeed demand is specified to depend negatively on the real price of coarse grain and positively on the real price of related products and real national income, representing consumer demand capacity.

The traditional inventory demand theory assumes that inventories are part of the total demand. The speculators will stock so long as the marginal cost and return (measured by the difference in the expected and observed prices) of stockholding are equal. Others have argued that agricultural inventories can increase as general economic activities expand for two reasons: (1) the necessary time lags in moving grain through marketing channels, and (2) processors' precautionary motives to stockpile to meet production goals (Labys, 1973).

Heien (1977) suggested that inventories, to the extent that they are a measure of market disequilibrium, determine the rate of price adjustment. However, the application of the disequilibrium approach by Gallagher et al. (1981) did not produce satisfactory results. The model used by Gallagher et al. used annual data. The equilibrium, however, occurs within one crop year. The disequilibrium approach, however, can be applied to quarterly data.

The inventory demand specification (Equation 6) in Table 3.1 utilized in this study assumes two motives for stockpiling: (1) transactional and (2) speculative. Therefore, the desired ending transaction demand is assumed to be a function of current production. Desired speculative demand is a function of real price in the current period. If linear functions are assumed, then the sum of the two desired ending stocks (EI_t^*) can be presented as:

$$EI_t^* = f(\overset{(+)}{QP_t}, \overset{(-)}{\frac{CWP_t}{CPI_t}})$$

where the variables are as defined in Table 3.2 for any region in the model.

Assume that stockholders adjust their inventories only partially toward their desired or equilibrium level in each period. This partial adjustment may result from a budget constraint associated with the speed of adjustment. To adjust quickly to the desired level requires higher adjustment costs. Therefore, assume that the beginning stock is partially adjusted only some fraction k of the distance required to reach the desired or equilibrium ending stock:

$$(EI_t - BI_t) = k(EI_t^* - BI_t); \quad 0 \leq k \leq 1.$$

Solving for EI_t,

$$EI_t = k \cdot EI_t^* + (1-k) \cdot BI_t.$$

Plugging the first of the above three equations into the last yields Equation (6) for the U.S. ending inventory of coarse grain in Table 3.1.

As explained earlier, the trading behavior of the remaining major regions are expressed by their reduced form net trade relationships. Equations (8, 10, 12, 14, 16, 18, 20) in Table 3.1, are the net trade equations for Japan, the USSR, Argentina, Canada, Australia, South Africa, and Thailand, respectively. Net trade of the EEC, China, Eastern Europe, and LDCs are aggregated into one variable and treated as the exogenous part of the world coarse grain market in the international trade flow linkage Equation (23) in Table 3.1. This is justified for reasons given in Chapter II. For example, European Economic Community's Common Agricultural Policy prevents any transmission of the world price fluctuations on their domestic market. In Eastern Europe, the official domestic prices are set by fiat without regard for world market price. In China, the volume of trade is exogenously determined by a state agency. In all cases, from the perspective of the rest of the world, the domestic market structure is not affected by world market conditions.

For those endogenous countries, excluding the United States, that permit world market price adjustments to be reflected directly in their domestic markets, the following general model of a small country market i is used to derive their net trade behavioral equations under the assumption that markets are perfectly competitive:

$$(23.1) \quad Q_i^D = f(\overset{(-)}{P_i}, \overset{(+)}{P_i^C}, \overset{(+)}{PL_i}, \overset{(+)}{AU_i}, X_i)$$

$$(23.2) \quad Q_i^S = f(\overset{(+)}{Q_i^P}, \overset{(+)}{I_i})$$

$$(23.3) \quad E_i = Q_i^S - Q_i^D$$

where

Q_i^D = total coarse grain demand in period t;

P_i = coarse grain price in period t;

P_i^C = coarse grain competitor crop price in period t;

PL_i = livestock and product price in period t;

Q_i^P = coarse grain production in period t;

AU_i = number of grain consuming animal units in period t;

Q_i^S = total coarse grain supply in period t;

I_i = beginning coarse grain inventory in period t;

E_i = excess demand (or supply) in period t;

X_i = any other demand shifter, such as changes in taste or consumption patterns.

The coarse grain demand Equation (23.1) is the total coarse grain demand, i.e., feed, nonfeed, and ending inventory demands. Its derivation is based on the economic theory used for the United States demand. The supply Equation (42), however, follows Nerlove's argument that in the current period production (Q_i^P) is predetermined through variables observed in the previous period (Labys, 1973). Furthermore, supply is not equal to production. Rather, it is a fraction of the production and the beginning inventory. Abbott (1976) indicates that in small countries, the fraction of production and beginning inventory which is actually supplied to the markets, depends upon the urban/ rural terms of trade.

By plugging Equations (23.1) and (23.2) into (23.3), one can express the net trade as a function of domestic price and all other variables in the system. The net trade equation for the regions listed above in Table 3.1 are derived in this way.

Equations (9, 11, 13, 15, 17, 19) in Table 3.1 are the required price linkage equations. The price differences among regions are accounted for by different tariffs, domestic taxes, subsidies, and transportation costs.

The relationship of the domestic price of any region i and the world price in the domestic currency is derived as follows:

$$(45) \quad P_t^i = A^i + B^i(E \cdot P_t^w)$$

where

P_t^i = domestic price of country i in period t;

P_w = a world price;

E = exchange rate of country i;

A^i = level of domestic shock barrier of the world price transmission

B^i = level of the degree of the world price fluctuation transmitted to the domestic price.

If any fluctuation in the world price is fully transmitted to domestic price, i.e., transmission is one-to-one, then we expect $A^i \neq 0$ and $B^i = 1$.

Thus, any difference between the domestic and world price levels measured in domestic currency is due to transportation cost and other additive factors.

Given a set of price linkage equations, the "world" price could be any one of the regional prices. In this model, Japan's price is used to link all regions.

For reasons explained in Chapter II, the price variable used for the USSR is the U.S. coarse grain price in ounces of gold. Therefore, Equation (11) is used as the price linkage for the USSR (see Appendix B).

The primary objective of this study is to assess the impact of U.S. monetary policy on the world coarse grain market through its effect on the U.S. exchange rate. Therefore, the exchange rate must be endogenous in the model. As will be illustrated below, the monetary approach to exchange rate determination provides the theoretical basis to explain exchange rate movements by the money supply and other variables (Equation 7, Table 3.1).

The U.S. exchange rate variable in this model (E8US) is defined as the value of a dollar in terms of Japanese yen. Japan is chosen because it is one of the leading trade partners of the United States. In addition, Japan is the largest coarse grain importing country after the EEC.

The remainder of this chapter is devoted to the determination of exchange rate under the monetary approach and the derivation of the exchange rate (Equation 8).

Monetary approach to exchange rate determination

If the balance of payments is divided into more than two accounts, for example, the current, capital, and money accounts, then each account can be explained with a direct or an indirect approach. Using the demands and supplies for the k^{th} item as a classification procedure for explaining the k^{th} account constitutes the direct approach. An account can be explained indirectly by first explaining the other n-1 accounts and then adding the results. Monetary economists argue that the tradition has been to explain current and capital accounts directly. Therefore, the money account (or the settlement account) should receive symmetric treatment.

By Walras' Law, the net excess supply of goods and securities by residents of a country represent a net excess demand for money. Thus, the traditional approach to the balance of payments that specified behavioral relationships for the trade and capital accounts contained an implicit monetary condition. However, the condition was not necessarily one that would have seemed reasonable if money supply and demand functions had been developed explicitly.

Johnson (1977) specifies the money market of a country under flexible exchange rates, in this case Japan, as:

$$M_d^j = P^j . L^j(\overset{(+)}{y^j}, \overset{(-)}{r^j})$$

$$M_d^j = M_s^j \equiv \text{exogenous}$$

where

M_d^j = Japan nominal money demand;

P^j = Japan general price level;

y^j = Japan real income;

r^j = Japan interest rate;

M_s^j = Japan exogenous money supply.

The assumptions are: (1) the demand for money is a stable function of a few independent variables, and (2) demand is homogeneous of degree one in price.

Adding the purchasing power parity equation allows one to examine the effects of changes in the money supply and/or demand on Japan's exchange rate. For Japan, this equation is:

$$P^j = e \cdot P^{us}$$

where

P^j = Japan general price level;

e = Japan exchange rate, yen/US \$;

P^{us} = U.S. general price level.

Combining these equations yields the following equation:

$$M_s^j = P^j \cdot L^j(y^j, r^j).$$

Rewriting this equation in terms of rate of growth yields:

$$G_s^j = G_p^j + E_y^j \cdot G_y^j + E_r^j \cdot G_r^j$$

where

G_s^j = Japan rate of growth of money supply;

G_p^j = Japan rate of growth of general price level;

E_y^j = Japan real income elasticity of money demand;

G_y^j = Japan rate of growth of real income;

E_r^j = Japan interest rate elasticity of money demand;

G_r^j = Japan rate of growth of interest rate.

Writing the purchasing power parity equation in terms of growth rates and substituting the result for G_p^j in the above equation yields:

$$G_s^j = G_p^{us} + G_e + E_y^j \cdot G_y^j + E_r^j \cdot G_r^j$$

where

G_p^{us} = U.S. rate of growth of general price level;

G_e = rate of growth of exchange rate.

Solving for G_e yields:

$$G_e = G_s^j - (G_p^{us}+E_y^j.G_y^j+E_r^j.G_r^j).$$

The above equation states that an increase in the rate of growth of Japan's money supply will depreciate the value of the Japanese yen, ceteris paribus. Similarly, given all other variables, an increase in the rate of growth of Japan's real income will appreciate the value of the Japanese currency; and an increase in the rate of growth of Japanese interest rate causes the Japanese currency to depreciate in value.

The intuition behind the above deductions is based on the money market. The term in parentheses above represents changes in the Japanese demand for money. The Japanese currency will depreciate if the demand for money declines relative to the supply. Because the interest rate elasticity of money demand is negative, for example, an increase in the interest rate will reduce the quantity of money demanded and cause the currency to depreciate in value.

A similar equation can be derived for the United States. Obviously, any variable affecting U.S. money supply or demand will have an opposite effect on e as compared to the same Japanese variable affecting Japanese money supply or demand, *ceteris paribus*.

Derivation of the exchange rate equation

To link e to the monetary sectors of the United States and Japan, the money market equilibrium conditions of both countries and the purchasing power parity equation are needed:

$$M_s^{us} = P^{us} \cdot L^{us}(y^{us}, r^{us})$$

$$M_s^{j} = P^{j} \cdot L^{j}(y^{j}, r^{j})$$

$$P^{j} = e \cdot P^{us}$$

where

for k = j (Japan), us (the United States);

M_s^k = country k money supply;

P_s^k = country k general price level;

L^k = country k real money demand;

y^k = country k real income;

r^k = country k interest rate;

e = value of U.S. dollar in Japanese yen.

By solving for P^j and P^{us} in the first two equations above and plugging into the third equation, the exchange rate can be defined by the following:

$$e = \left(\frac{M_s^j}{M_s^{us}}\right) \cdot \left(\frac{L^{us}}{L^j}\right) .$$

Taking the logarithmic time differential (denoted by ".") of the above equation yields:

$$\dot{e} = (\dot{M}_s^j - \dot{M}_s^{us}) + (\dot{L}^{us} - \dot{L}^j).$$

The first term in parentheses in this equation represents the effects of nominal monetary changes on the exchange rate. Given other variables, this implies that an increase in Japanese money supply will increase e (a depreciation of the yen). Similarly, as was argued in the preceding section, an increase in the U.S. money supply will decrease e (a depreciation of the dollar), ceteris paribus. The second term in parentheses in the above equation captures the effects of changes in real money demand. Other variables constant, an increase in the U.S. real demand for money will increase e (an appreciation of the dollar). Similarly, an increase in the Japan real demand for money will decrease e (an appreciation of the yen), ceteris paribus.

Given that the real demand for money, under the monetary approach, is a stable function of a few variables, the last equation can be written, in functional form, to have the following directional relationships:

$$e = f(\overset{(+)}{M_s^j},\ \overset{(-)}{y^j},\ \overset{(+)}{r^j},\ \overset{(-)}{M_s^{us}},\ \overset{(+)}{y^{us}},\ \overset{(-)}{r^{us}}).$$

The partial derivative signs can be explained intuitively by the money markets. An increase in the money stock of any currency brings about an excess supply of money, which puts a downward pressure on the value of that currency ($\frac{\partial e}{\partial m_s^j} > 0$, $\frac{\partial e}{\partial m_s^{us}} < 0$). Given that income elasticity of money demand (E_y^j or E_y^{us}) is positive, an increase in the income of any country brings about an excess demand for money, which puts an upward pressure on the value of the country's currency ($\frac{\partial e}{\partial y^j} < 0$, $\frac{\partial e}{\partial y^{us}} > 0$). Finally, under the assumption that interest rate elasticity of money demand (E_r^j, E_r^{us}) is negative, an increase in interest rate of any country depresses demand for money and brings about an excess supply of money, which puts a downward pressure on the value of the country's currency ($\frac{\partial e}{\partial r^j} > 0$, $\frac{e}{\partial r^{us}} < 0$).

The mathematical model developed in this chapter and given in Table 3.1, can be divided into two components: the world coarse grain market and the exchange rate determination system. The exchange rate component was developed above and consists of one equation explaining movements in the value of the U.S. dollar. In this equation, the exchange rate is a function of only exogenous variables and could, therefore, be estimated separately from the other equations in the model. However, the 1960-80 period of study consists of both fixed and flexible exchange rate regimes. Consequently, the explanatory variables of the exchange rate equation as developed above had no effect on the dependent variable for the period over which the exchange rate was fixed. In recognition of this fact, a grafted polynomial technique (Fuller, 1976) will be used to estimate the parameters of the exchange rate equation (see Chapter IV for more detail).

Although the flexible regime was adopted officially in 1973, a transition from a fixed to flexible exchange rate system occurred between 1971 and 1973 during which currency devaluations became the common alternative to government interventions to keep exchange rates fixed.

The mathematical model presented in Table 3.1 is capable of assessing the impacts of monetary policy on the world coarse grain market through endogenizing the exchange rate. The model consists of nine regions, of which eight are endogenous. The last region is the exogenous rest-of-the-world coarse grain trade. The model is composed of 23 equations (equal to the number of endogenous variables), some of which are nonlinear.

The following chapter discusses the nonlinearity of the model and estimation procedure, and reports the results of the estimation.

CHAPTER IV. EMPIRICAL ANALYSIS

This chapter is divided into two main sections: estimation and validation. The former section reports the properties of the model, estimation procedure, and the results. The second section is devoted to the validation of the model.

Estimation

The mathematical structure of the world coarse grain market component of the model as described in Chapter III is nonlinear. In general, fundamental identities as well as many other basic variables (e.g., relative prices) form ratios that render the model nonlinear. The estimation technique used for this component is the two stage least square procedure (Amemiya, 1974). Consider a nonlinear equation to be:

$$y_t = f(z_t, B) + \mu_t$$

where y_t is a scalar dependent variable, μ_t is a scalar random variable with zero mean and constant variance σ^2, z_t is composed of g endogenous variables (that is, independent variables correlated with μ_t) and k exogenous variables (that is, known constants), B is the vector of unknown parameters, and f is a nonlinear function. The function is assumed to have continuous first and second derivations with respect to B.

Amemiya shows that under certain large sample assumptions, the two stage least squares estimation of B (denoted $\hat{B}$) will be asymptotically unbiased with normal distribution. The assumptions are:

(1) $\{\mu_t\}$ is identically and independently distributed;

(2) $\lim(1/n)X'X$ exists and is nonsingular where X is the m x k matrix of exogenous variables with rank k;

(3) $(1/n)(\partial f/\partial B)X$ converges in probability to a constant matrix of rank g uniformly in B;

(4) $(1/n)(\partial^2 f'/\partial B_i \partial B)X$ converges in probability to a constant matrix uniformly in B for all $i = 1,\ldots,g$, where B_i is the ith element of B.

The principal component technique is applied in the first stage of the estimation process. The technique is used because the number of exogenous variables exceeds the number of observations. Ten principal components are calculated from all the exogenous variables and are then used as the instrumental variables in the first stage.

Estimation of the exchange rate component requires application of the grafted polynomial technique (Fuller, 1976). As was explained in Chapter III, over the period of the fixed exchange rate regime (1960-1970), movements in the dollar exchange rate were not determined by the explanatory variables in the exchange rate equation as developed in Chapter III. Consequently, estimation of Equation (7) in Table 3.1 over the entire time period of analysis, is not appropriate. An alternative approximation that overcomes this problem is to approximate discrete segments of the exchange rate function and then join those segments to form a continuous function. This function is referred to as a grafted polynomial.

The application of the grafted polynomial in the estimation of the mean function of the exchange rate equation in this study is based on the assumption that the time series can be divided into three segments: (1) fixed exchange rates (1960-1970), (2) an adjustment period (1971-1973), and (3) flexible rates (1974-1980). The "grafted polynomial variable", z, is defined to be:

$$z = 0, \qquad \text{Year} \leq 1970$$

$$z = \text{Year}-1970, \qquad 1971 \leq \text{Year} \leq 1973$$

$$z = 4 \qquad \text{Year} \geq 1974 .$$

The grafted form of Equation (7) can then be represented as:

$$E8US = f(z, z\cdot MS1,\ z\cdot RDY1,\ z\cdot DR1,\ z\cdot MS8,\ z\cdot RDY8,\ z\cdot DR8).$$

It should be noted that the estimated statistics must be adjusted for the degrees of freedom. This is because z is defined to be zero for the period 1960-1970, which removes the possibility of estimating any residual for each observation of the period 1960-1970.

The estimated or structural model is shown below in Table 4.1. Each equation includes the estimated coefficients, t-statistics (parentheses), elasticities of major variables

Table 4.1. Estimated model of the world coarse grain market

$$(1)\quad QPCRN1_t \equiv YLDCRN1_t * AHCRN1_t$$

$$(2)\quad QPSOR1_t \equiv YLDSOR1_t * AHSOR1_t$$

$$(3)\quad QPBAR1 \equiv YLDBAR1_t * AHBAR1_t$$

$$(4)\quad QPOAT1_t \equiv YLDOAT1_t * AHOAT1_t$$

$$(5)\quad QP1_t \equiv QPCRN1_t + QPSOR1_t + APBAR1_t + QPOAT1_t$$

$$(6)\quad AHCRN1_t = \underset{(-1.02)}{-2.259} + \underset{(29.39)}{0.889} * APCRN1_t$$

D.F. = 17 $\quad R^2 = 0.9806 \quad$ DW = 1.40

$$(7)\quad AHSOR1_t = -0.779 + 0.837 * APSOR1_t$$

D.F. = 17 $\quad R^2 = 0.6962 \quad$ DW = 1.13

$$(8)\quad AHBAR1_t = \underset{(3.27)}{1.434} + \underset{(18.55)}{0.767} * APBAR1_t$$

D.F. = 17 $\quad R^2 = 0.9527 \quad$ DW = 1.04

Table 4.1 (Continued)

(9) $AHOAT1_t = -1.929 + 0.837*APOAT1_t$
$\quad\quad\quad\quad (-2.93) \quad (26.99)$

D.F. = 17 R^2 = 0.9771 DW = 1.63

(10) $APCRN1 = 30.76 + 12.46*\frac{LFPCRN1_t}{LIPPF1_t}$
$\quad\quad (1.75) \quad (1.46)$
$\quad\quad\quad\quad [0.08]$

$- 7.905*\frac{LFPSOB1_t}{LIPPF1_t} - 123.7*\frac{EDRC_t}{IPPF1_t}$
$(-2.04) \quad\quad (-4.18)$
$[-0.111] \quad\quad [-0.064]$

$+ 14.75*\frac{ESRC_t}{IPPF1_t} + 0.541*APCRN1_{t-1}$
$(1.86) \quad\quad (1.71)$
$[0.063]$

$+ 0.50*YEAR$
(2.87)

D.F. = 12 R^2 = 0.966 DW = 2.06

Table 4.1 (Continued)

$$(11)\quad APSOR1_t = \underset{(6.36)}{24.95} + \underset{\substack{(2.05)\\ [0.229]}}{3.921}*\frac{USAPPRSS_t}{LFPWHT1_t}$$

$$-\underset{\substack{(-2.82)\\ [-0.636]}}{5.466}*EDRS_t - \underset{\substack{(-4.32)\\ [-0.289]}}{0.008}*ESRCOT_t$$

$$+\underset{(3.11)}{2.326}*DUM661 - \underset{(-1.56)}{.07*10^{-6}}*YEAR$$

D.F. = 13 R^2 = .7595 DW = 1.85

$$(12)\quad APBAR1_t = \underset{(4.13)}{114.1} + \underset{\substack{(3.57)\\ [0.503]}}{5.583}*\frac{USAPPRBB_t}{LFPOAT1_t}$$

$$+ \underset{(5.07)}{.15*10^{-6}}*ADWHT1_t - \underset{(-4.39)}{1.766}*DUMW$$

$$+ \underset{(2.99)}{0.016}*TIME2 - \underset{(-3.46)}{2.701}*YEAR$$

D.F. = 13 R^2 = 0.8911 DW = 2.92

Table 4.1 (Continued)

$$(13)\quad APOAT1_t = \underset{(3.05)}{253.5} + \underset{\substack{(1.50)\\ [0.282]}}{6.47}*\frac{USAPPROO_t}{LFPBAR1_t}$$

$$+ \underset{(1.74)}{0.07}*10^{-6}*ADWHT1_t + \underset{(3.00)}{4.814}*DUM681$$

$$+ \underset{(2.25)}{0.033}*TIME2 - \underset{(-2.62)}{5.798}*YEAR$$

D.F. = 13 R^2 = .9783 DW = 1.84

$$(14)\quad LFPCRN1_t = \underset{(-0.82)}{-1.284} + \underset{(45.03)}{0.935}*CWP1_{t-1}$$

D.F. = 17 R^2 = 0.9917 DW = 1.99

$$(15)\quad USAPPRSS_t = \underset{(-6.08)}{-22.47} + \underset{(21.43)}{1.05}*CWP1_{t-1}$$

D.F. = 17 R^2 = 0.964 DW = 1.62

$$(16)\quad USAPPRBB_t = \underset{(-5.26)}{-29.33} + \underset{(17.04)}{1.259}*CWP1_{t-1}$$

D.F. = 17 R^2 = 0.9438 DW = 1.86

Table 4.1 (Continued)

(17) $USAPPROO_t = \underset{(-0.02)}{-0.13} + \underset{(11.17)}{0.87}*CWP1_{t-1}$

D.F. = 17 R^2 = 0.8782 DW = 1.44

(18) $FD1_t = \underset{\substack{(-3.79)\\[-0.359]}}{-32.16}*\frac{CWP1_t}{CPI1_t} + \underset{\substack{(2.79)\\[0.129]}}{6.31}*\frac{WPSOM1_t}{CPI1_t}$

$+\underset{\substack{(4.05)\\[0.924]}}{74.80}*\frac{PL1_t}{CPI1_t} + \underset{\substack{(1.94)\\[1.05]}}{0.493}*GCAU1_t$

D.F. = 15 R^2 = 0.9332 DW = 2.03

(19) $NFD1_t = \underset{(2.63)}{93.89} - \underset{\substack{(-1.66)\\[-0.595]}}{0.171}*\frac{CWP1_t}{WPIX1_t} + \underset{(3.35)}{0.64}*NFD1_{t-1}$

$+ \underset{(2.68)}{0.021}*TIME2 - \underset{(-2.66)}{2.727}*YEAR$

D.F. = 14 R^2 = 0.9919 DW = 2.86

Table 4.1 (Continued)

$$(20)\quad EI1_t = \underset{(2.04)}{23.24} + \underset{\substack{(3.70)\\ [0.679]}}{0.165*QP1_t} - \underset{\substack{(-4.74)\\ [-0.728]}}{17.16*\frac{CWP1_t}{CPI1_t}}$$

$$+ \underset{(8.29)}{1.182*SGI1_t}$$

D.F. = 15 R^2 = 0.9155 DW = 1.76

$$(21)\quad LE8US_t = \underset{(330.527)}{5.887} - \underset{(-1.115)}{0.802*Z_t} - \underset{\substack{(-0.735)\\ [-0.17]}}{0.165*Z_t*LMS1_t}$$

$$-\underset{\substack{(-4.073)\\ [-0.104]}}{0.104*Z_t*LDR1_t} + \underset{\substack{(0.889)\\ [0.017]}}{0.168*Z_t*LMS8_t}$$

$$+ \underset{\substack{(2.776)\\ [0.061]}}{0.016*Z_t*LDR8_t}$$

D.F. = 4 R^2 = 0.9789 DW = 2.54

$$(22)\quad E8US_t = EXP(LE8US_t)$$

Table 4.1 (Continued)

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(23) $$NMT8_t = \underset{(-2.48)}{-5.731} - \underset{\substack{(-2.50)\\ [-0.339]}}{0.173*10^{-3}}*\frac{WPCRN8_t}{WPI8_t}$$

$$+\underset{\substack{(2.99)\\ [0.3449]}}{0.002}*\frac{WPSOM8_t}{WPI8_t} + \underset{\substack{(18.38)\\ [1.58]}}{0.001}*GCAU8_t$$

$$\underset{(-3.83)}{-0.002}*RICEFED8_t$$

D.F. = 14 R^2 = 0.9754 DW = 1.62

(24) $$WPCRN8_t = \underset{(1.84)}{119.3} + \underset{\substack{(9.83)\\ [1.05]}}{1.241}*E8US_t*CWP1_t$$

D.F. = 17 R^2 = 0.8460 DW = 1.52

Table 4.1 (Continued)

$$\text{(25)}\quad NMT10_t = \underset{\substack{(-4.50)\\ [-1.106]}}{-6.014}*PRICE10_t + \underset{\substack{(3.15)\\ [7.161]}}{0.022}*RDY10_t$$

$$\underset{\substack{(-1.77)\\ [4.318]}}{-0.185}*QP10_t$$

$$D.F. = 16 \quad R^2 = 0.7359 \quad DW = 1.41$$

$$\text{(26)}\quad PRICE10_t \equiv \frac{CWP1_t}{PRGOLD78_t}$$

$$\text{(27)}\quad NXTCRN2_t = \underset{(-2.51)}{-14.35} + \underset{\substack{(1.57)\\ [0.601]}}{0.108}*\frac{NPRCRN2_t}{WGPI2_t}$$

$$+ \underset{(1.58)}{0.034}*\frac{NPRCRN2_{t-1}}{WGPI2_{t-1}} + \underset{\substack{(5.84)\\ [1.082]}}{0.604}*QPCRN2_t$$

$$+ \underset{(2.19)}{0.141}*YEAR$$

$$D.F. = 14 \quad R^2 = 0.8639 \quad DW = 2.42$$

Table 4.1 (Continued)

---

(28) $$NXTSGM2_t = 0.0197*\frac{NPRGSM2_t}{WGPI2_t} + 0.672*QPSGM2_t$$

(0.71) (10.64)

[0.210] [0.130]

$$+ 1.59*QISGM2_t - 0.016*YEAR$$

(0.98) (-1.33)

D.F. = 15 R^2 = 0.9584 DW = 1.24

(29) $$NPRCRN2_t = -0.34*10^6 + 1.117*10^6*E2JA_t*WPCRN8_t$$

(-1.16) (24.14)

[1.237]

D.F. = 17 R^2 = 0.9716 DW = 1.82

(30) $$NPRSGM2_t = -0.34*10^6 + 0.959*10^6*E2JA_t*WPCRN8_t$$

(-1.11) (19.76)

[1.263]

D.F. = 17 R^2 = 0.9581 DW = 1.66

Table 4.1 (Continued)

$$(31)\quad NXT3_t = \underset{\substack{(2.19)\\ [1.307]}}{1.805}*\frac{BARWP3_t}{DEF3_t} - \underset{\substack{(-4.93)\\ [-4.567]}}{9.304}*\frac{PL3_t}{DEF3_t}$$

$$+ \underset{\substack{(7.60)\\ [3.157]}}{0.37}*QP3_t + \underset{(2.24)}{0.387}*BI3_t$$

D.F. = 15 R^2 = 0.8596 DW = 2.23

$$(32)\quad BARWP3_t = \underset{(0.61)}{3.427} + \underset{\substack{(14.83)\\ [0.804]}}{0.777}*E3JA_t*WPCRN8_t$$

D.F. = 17 R^2 = 0.9278 DW = 1.29

$$(33)\quad NXT4_t = \underset{(-3.93)}{-3.719} + \underset{\substack{(1.89)\\ [0.769]}}{0.986}*\frac{CGP4_t}{DEF4_t}$$

$$+ \underset{\substack{(3.96)\\ [0.693]}}{0.288}*QP4_t + \underset{(2.36)}{0.814}*BI4_t$$

Table 4.1 (Continued)

(33) Cont.

$$-0.271*10^{-3}*GCAU4_t$$
$$(2.64)$$
$$[-1.329]$$

D.F. = 14 R^2 = 0.8898 DW = 1.96

(34)

$$CGP4_t = \underset{(-0.84)}{-7.563} + \underset{\substack{(8.61)\\ [1.168]}}{0.929}*E4JA$$

D.F. = 17 R^2 = 0.8116 DW = 1.47

(35)

$$NXT5_t = \underset{\substack{(4.75)\\ [1.727]}}{0.499}*QP5_t + \underset{(1.81)}{0.068}*BI5_t$$

$$\underset{\substack{(-1.75)\\ [-0.704]}}{-0.107}*\frac{GNP5_t}{DEF5_t}$$

D.F. = 16 R^2 = 0.8521 DW = 1.92

Table 4.1 (Continued)

---

(36) $NXT6_t = -6.782 + 0.0123*\frac{EXPRCRN6_t}{CPI6_t}$

(-3.49) (1.61)
[0.266]

$-0.009*\frac{GNP6_t}{CPI6_t} + 0.683*QPI6_t$

(-4.28) (6.10)
[-0.840] [1.0]

$+0.111*YEAR$
(3.42)

D.F. = 14 $R^2 = 0.9584$ DW = 2.47

(37) $EXPRCRN6_t = -103.4 + 0.969*E6JA*WPCRN8_t$

(-1.23) (1.61)
[1.05]

D.F. = 17 $R^2 = 0.9704$ DW = 1.43

(38) $NXT1_t \equiv (QP1_t+BI1_t) - (FD1_t+NFD1_t+EI1_t+SEEDC1_t$

Table 4.1 (Continued)

$$(39)\quad NXT1_t \equiv (NMT8_t + NMT10_t + NMTREST_t) - (NXTCRN2_t + NXTSGM2_t + NXT3_t + NXT4_t + NXT5_t + NXT6_t)$$

Table 4.2. Variables used in the world coarse grain market, variable names, descriptions, units, and data sources

Name	Description	Unit	Source[a]
List of endogenous variables:			
QPCRN1$_t$	U.S. corn production, Oct./Sept.	million metric tons	MSDB, 1982[b]
QPSOR1$_t$	U.S. sorghum production, Oct./Sept.	million metric tons	MSDB, 1982
QPBAR1$_t$	U.S. barley production, June/May	million metric tons	MSDB, 1982
QPOAT1$_t$	U.S. oat production, June/May	million metric tons	MSDB, 1982
AHCRN1$_t$	U.S. corn acreage harvested, Oct./Sept.	million acres	MSDB, 1982
AHSOR1$_t$	U.S. sorghum acreage harvested, Oct./Sept.	million acres	MSDB, 1982
AHBAR1$_t$	U.S. barley acreage harvested, June/May	million acres	MSDB, 1982
AHOAT1$_t$	U.S. oat acreage harvested, June/May	million acres	MSDB, 1982
APCRN1$_t$	U.S. corn acreage planted, Oct./Sept.	million acres	MSDB, 1982
APSOR1$_t$	U.S. sorghum acreage planted, Oct./Sept.	million acres	MSDB, 1982
APBAR1$_t$	U.S. barley acreage planted, June/May	million acres	MSDB, 1982
APOAT1$_t$	U.S. oat acreage planted, June/May	million acres	MSDB, 1982

[a]For complete reference, see bibliography.

[b]Modeling system data bank.

Table 4.2 (Continued)

Name	Description	Unit	Source
$FD1_t$	U.S. coarse grain consumption as feed, Oct./Sept.	million metric tons	USDA, FAC[c], 1976a-1982a
$NFD1_t$	U.S. industrial coarse grain consumption, Oct./Sept.	million metric tons	USDA-FAC, 1976a-1982a
$EI1_t$	U.S. coarse grain inventory, Oct./Sept.	million metric tons	USDA-FAC, 1976a-1982a
$QP1_t$	U.S. coarse grain production, Oct./Sept.	million metric tons	USDA-FAC, 1976a-1982a
$LE8US_t$	Log of U.S. annual exchange rate	Jap. yen/US $	IMF-IFS,[d] 1981
$E8US_t$	U.S. annual exchange rate, period average	Jap. yen/US $	IMF-IFS, 1981
$NMT8_t$	Japan net coarse grain imports, July/June	million metric tons	USDA-FAC 1976a-1982a
$WPCRN8_t$	Japan wholesale corn price, Apr./Mar.	yen/MT	Coyle, 1983
$NMT10_t$	USSR net coarse grain imports, July/June	million metric tons	USDA-FAC, 1976a-1982a
$PRGOLD78_t$	U.S. gold price, calendar year	U.S. $/ounce	IMF-IFS, 1981

[c] U.S. Department of Agriculture, Foreign Agricultural Circular.

[d] International Monetary Fund, International Financial Statistics.

Table 4.2 (Continued)

Name	Description	Unit	Source
$\mathrm{PRICE10}_t$	U.S. coarse grain price in gold	ounces/MT	MSDB, 1982; IMF-IFS, 1981
$\mathrm{NXTCRN2}_t$	Argentina net corn exports, Mar./Feb.	million metric tons	USDA-UNP[e]
$\mathrm{NXTSGM2}_t$	Argentina net sorghum exports, Mar./Feb.	million metric tons	USDA-UNP
$\mathrm{NPRCRN2}_t$	Argentina wholesale corn price, Mar./Feb.	pesos/MT	Gogna y Cia, 1983
$\mathrm{NPRSGM2}_t$	Argentina wholesale sorghum price, Mar./Feb.	pesos/MT	Gogna y Cia, 1983
$\mathrm{NXT3}_t$	Canada net coarse grain exports, July/June	million metric tons	USDA-FAC 1976a-1982a
$\mathrm{BARWP3}_t$	Canada wholesale barley price, Aug./July	Can. $/MT	USDA-UNP
$\mathrm{NXT4}_t$	Australia net coarse grain exports, July/June	million metric tons	USDA-FAC 1976a-1982a
$\mathrm{CGP4}_t$	Australia unit value of coarse grain export	Aust. $/MT	USDA-UNP
$\mathrm{NXT5}_t$	South Africa net coarse grain exports, July/June	million metric tons	USDA-FAC 1976a-1982a
$\mathrm{NXT6}_t$	Thailand net coarse grain exports, July/June	million metric tons	USDA-FAC 1976a-1982a

[e]Data provided by the U.S. Department of Agriculture from unpublished sources.

Table 4.2 (Continued)

Name	Description	Unit	Source
$EXPRCRN6_t$	Thailand corn export price, calendar year	baht/MT	USDA-UNP
$NXT1_t$	U.S. coarse grain exports, July/June	million metric tons	USDA-FAC 1976a-1982a
$CWP1_t$	U.S. consumption weighted price of the U.S. coarse grain farm prices	U.S. $/MT	MSDB, 1982
$LFPCRN1_t$	Lag of U.S. farm price of corn in period t, Oct./Sept.	U.S. $/MT	MSDB, 1982
$USAPPRSS_t$	U.S. effective support rate of sorghum up to 1972 and lag of farm price of sorghum thereafter, Oct./Sept.	U.S. $/MT	MSDB, 1982; Womack et al., 1976
$USAPPRBB_t$	U.S. effective support rate of barley up to 1972 and lag of farm price of barley thereafter, June/May	U.S. $/MT	MSDB, 1982; Womack et al., 1976
$USAPPROO_t$	U.S. effective support rate of oats up to 1972 and lag of farm price of oat thereafter, June/May	US $/MT	MSDB, 1982; Womack et al., 1976
List of exogenous variables:			
$YLDCRN1_t$	U.S. corn yield, Oct./Sept.	MT/acre	MSDB, 1982
$YLDSOR1_t$	U.S. sorghum yield, Oct./Sept.	MT/acre	MSDB, 1982

Table 4.2 (Continued)

Name	Description	Unit	Source
$YLDBAR1_t$	U.S. barley yield, June/May	MT/acre	MSDB, 1982
$YLDOAT1_t$	U.S. oat yield, June/May	MT/acre	MSDB, 1982
$LFPSOB1_t$	Lag of U.S. farm price of soybeans in period t, Aug./July	US $/MT	MSDB, 1982
$EDRC_t$	U.S. effective diversion rate of corn, Oct./Sept.	US $/MT	MSDB, 1982
$ESRC_t$	U.S. effective support rate of corn, Oct./Sept.	U.S. $/MT	MSDB, 1982
$APCRN1_{t-1}$	U.S. corn acreage planted in period t-1, Oct./Sept.	million acres	MSDB, 1982
$IPPF1_t$	Index of U.S. prices paid by farmers for all commodities used in production	1980 = 1.0	USDA, AGP[f] 1980b
$YEAR_t$	Time trend	1960,...1980	-
$LFPWHT1_t$	Lag of U.S. farm price of wheat in period t, July/June	US $/MT	MSDB, 1982
$EDRS_t$	U.S. effective diversion rate of sorghum, Oct./Sept.	US $/MT	MSDB, 1982

[f] U.S. Department of Agriculture, Agricultural Prices.

Table 4.2 (Continued)

Name	Description	Unit	Source
$ESRCOT_t$	U.S. effective support rate of cotton, Aug./July	US $/MT	MSDB, 1982
$DUM661_t$	Dummy variable representing change in calculation of effective support rates	(1960-65) = 0 (otherwise) = 1	Womack et al., 1976
$LFPOAT1_t$	Lag of U.S. farm price of oat in period t, June/May	U.S. $/MT	MSDB, 1982
$ADWHT_1$	U.S. wheat acreage diverted, July/June	million acres	MSDB, 1982
$DUMW_t$	Dummy variable reflecting bad weather conditions	(1965, 1972, 1977) = 1 (otherwise) = 0	-
$Time2_t$	Dummy variable to account for quadratic time trend	YEAR*YEAR	Womack et al., 1976
$LFPBAR1_t$	Lag of U.S. farm price of barley in period t, June/May	U.S. $/MT	MSDB, 1982
$LIPPF1_t$	Lag of $IPPF1_t$ in period t	1981 = 1.0	USDA, AGP, 1980b
$DUM681_t$	Dummy variable to reflect the influence from the introduction of chemical herbicides	(1960-1967) = 0 (otherwise) = 1	Womack et al., 1976
$CWP1_{t-1}$	Lag of consumption weighted price of the U.S. coarse grains farm prices	U.S. $/MT	MSDB, 1982
$WPSOM1_t$	U.S. wholesale soymeal price, Oct./Sept.	U.S. $/MT	MSDB, 1982

Table 4.2 (Continued)

Name	Description	Unit	Source
$CPI1_t$	U.S. consumer price index	1980 = 1.0	IMF-IFS, 1981
$PL1_t$	Index of producer price of U.S. livestock and products	1980 = 1.0	USDA-AGP, 1980b
$GCAU1_t$	U.S. number of grain consuming animal units, annual	million head	MSDB, 1982
$WPIX1_t$	U.S. wholesale price index	1980 = 1.0	IMF-IFS, 1981
$SGI1_t$	U.S. government coarse grain inventory, Oct./Sept.	million metric tons	USDA-UNP
$LMS1_t$	Log of U.S. money supply (M2)	billion dollars	IMF-IFS, 1981
$LDR1_t$	Log of U.S. discount rate	percent	IMF-IFS, 1981
$LMS8_t$	Log of Japan money supply (M2)	billion yen	IMF-IFS, 1981
$LDR8_t$	Log of Japan discount rate	percent	IMF-IFS, 1981
$DUM711_t$	Dummy variable reflecting the shift to flexible exchange rates	(1960-1970) = 0 (otherwise) = 1	Womack et al., 1976
$WPSOM8_t$	Japan soymeal wholesale price, Apr./Mar.	Yen/MT	Coyle, 1983
$WPI8_t$	Japan wholesale general price index	1980 = 1.0	Coyle, 1983
$GCAU8_t$	Japan grain consuming animal units, calendar year	1000 head	USDA-UNP

Table 4.2 (Continued)

Name	Description	Unit	Source
$RICEFED8_t$	Japan rice fed to animals, Apr./Mar.	1000 metric tons	Coyle, 1983
$RDY10_t$	USSR real income	billions of 1980 U.S. dollar	CIA, 1981[g]
$QP10_t$	USSR coarse grain production, July/June	million metric tons	USDA-FAC, 1976a-1982a
$WGPI2_t$	Argentina general wholesale price index, calendar year	1960 = 1.0	Gogna y Cia, 1983
$QPCRN2_t$	Argentina corn production, Mar./Feb.	million metric tons	Gogna y Cia, 1983
$QPSGM2_t$	Argentina sorghum production, Mar./Feb.	million metric tons	Gogna y Cia, 1983
$QISGM2_t$	Argentina sorghum beginning inventory, Mar./Feb.	million metric tons	Gogna y Cia, 1983
$PL3_t$	Canada weighted average price of livestock, calendar year	Can. $/CWT	USDA-UNP
$DEF3_t$	Canada implicit price deflator	1980 = 1.0	IMF-IMF, 1981
$QP3_t$	Canada coarse grain production, July/June	million metric tons	USDA-FAC 1976a-1982a
$BI3_t$	Canada beginning coarse grain inventory, July/June	million metric tons	USDA-FAC, 1976a-1982a
$DEF4_t$	Australia implicit price deflator, calendar year	1980 = 1.0	IMF-IFS, 1981

[g]Central Intelligence Agency.

Table 4.2 (Continued)

Name	Description	Unit	Source
$QP4_t$	Australia coarse grain production, July/June	million metric tons	USDA-FAC, 1976a-1982a
$BI4_t$	Australia beginning coarse grain inventory, July/June	million metric tons	USDA-FAC, 1976a-1982a
$GCAU4_t$	Australia grain consuming animal units	1000 head	USDA-UNP
$QP5_t$	South Africa coarse grain production, Oct./Sept.	million metric tons	USDA-FAC, 1976a-1982a
$GNP5_t$	South Africa gross national product, calendar year	million rand	IMF-IFS, 1981
$DEF5_t$	South Africa implicit price deflator, calendar year	1980 = 1.0	IMF-IFS, 1981
$BI5_t$	South Africa beginning inventory, Oct./Sept.	million metric tons	USDA-FAC, 1976a-1982a
$CPI6_t$	Thailand consumer price index, calendar year	1980 = 1.0	IMF-IFS, 1981
$GNP6_t$	Thailand gross national product, calendar year	billion baht	IMF-IFS, 1981
$QPI6_t$	Thailand total coarse grain supply, production and beginning inventory	million metric tons	USDA-FAC, 1976a-1982a
$SEEDC1_t$	U.S. coarse grain seed consumption, Oct./Sept.	million metric tons	USDA-FAC, 1976a-1982a

Table 4.2 (Continued)

Name	Description	Unit	Source
$BI1_t$	U.S. beginning coarse grain inventory, Oct./Sept.	million metric tons	USDA-FAC, 1976a-1982a
$NMTREST_t$	Rest of the world net imports of coarse grain, July/June	million metric tons	USDA-FAC, 1976a-1982a
$E2JA_t$	Argentina exchange rate, calendar year, period average	pesos/yen	IMF-IFS, 1981
$E3JA_t$	Canada exchange rate, calendar year, period average	Can. $/yen	IMF-IFS, 1981
$E4JA_t$	Australia exchange rate, calendar year, period average	Aus. $/yen	IMF-IFS, 1981
$E6JA_t$	Thailand exchange rate, calendar year, period average	baht/yen	IMF-IFS, 1981
Z_t	Grafted polynomial variable to join fixed to flexible exchange rate	(1960-1970)=0 (1971-1973)=year-70 (otherwise)=4	

(brackets), R-square, Durbin-Watson or Durbin h-statistic. Any interpretation concerning elasticities is done only sparingly in this analysis because derivatives are not strictly valid in such simultaneous models. Table 4.2 provides the variable names, descriptions, units, and sources of all time series used to estimate the model.

Equations (1-20) and (38) in Table 4.1 present the U.S. model. The coarse grain acreage planted equation, as specified in the last chapter (Table 3.1), had poor statistical properties. Therefore, Equation (3) in Table 3.1 was disaggregated. The estimated equations for acreage planted of sorghum, barley, and oats were specified in a manner similar to the theoretical model presented by Womack et al. (1976). The corn acreage Equation (10) in Table 4.1 features the lag of farm prices of corn and soybeans, the current year's effective support and diversion prices, and the lag of corn acreage planted. The statistical properties of this equation are good with almost 97 percent of historical variation in corn acreage explained; all variables have the correct sign and are significant at the 10 percent level. Corn acreage responds significantly to corn diversion policy as measured by the effective diversion rate. Acreage response is fairly inelastic with respect to corn and soybean prices. Results confirm the dominance of soybeans as a corn acreage substitute. Lag acreage is significant at the 10 percent level which indicates gradual adjustments to changing market conditions.

Sorghum acreage estimates are presented in Equation (11), Table 4.1. Commodities that complete for sorghum land are wheat and cotton. These two influences are captured in lagged wheat market price (LFPWHT1) and effective support price of cotton (ESRCOT). Following Houck et al. (1972), supply-inducing prices enter through a "spliced" variable (USAPPRSS) which is defined to be the effective support price of sorghum prior to 1972 and lagged farm price thereafter. Effective diversion payment rates are included in EDRS. A change in the method of calculating effective support prices after 1965 is reflected in DUM661. All variables have correct signs and the R-squared is reasonable.

Barley planted acreage response, Equation (12) in Table 4.1, is similar in specification to the sorghum equations. Competitive influence enters from oats and wheat with corresponding variable influence represented by their respective lagged farm prices (LFPOAT1 and ADWHT1). Also, a "spliced" market price variable (USAPPRBB) is utilized for government influence prior to 1972 and lagged farm price since 1972. The quadratic and linear time trend (TIME2 and YEAR) are used to capture technological influence from introduction of chemical herbicides. The dummy variable (DUMW) captures the influence of bad weather on planting. The statistical properties of this equation are quite good, with almost 90 percent of historical variation explained; all variables have the correct sign and are significant at .05 percent with the exception of TIME2 which is significant at the 10 percent level.

The planted oat acreage response, Equation (13) in Table 4.1, is again similar in specification to the other minor coarse grain equations. All variables have the correct sign and are significant at the 5 percent level with the exception of the "spliced" price variable (significant at the 15 percent level. Results indicate that the price elasticities of minor grains are somewhat larger than for corn, ranging from .503 for barley to .08 for corn.

Equations (14-17) in Table 4.1 relate farm prices of the individual grains to the lagged consumption weighted average price of coarse grain (CWP1).

Equations (18, 19, 20) in Table 4.1 present the U.S. demands for coarse grain. Except the nonfeed demand, the equations are similar to their specification in Equations (4, 5, 6) in Table 3.1. All lagged variables in Equation (18), Table 4.1, were statistically insignificant and were dropped. All other variables are highly significant with the correct signs. The feed demand is inelastic, reflecting the impediments to rapid adjustments by livestock producers. However, the livestock price elasticity of feed demand is almost one. The feed demand is elastic with respect to the number of grain consuming units (GCAU1). Because GCAU1 is highly correlated with income, this might reflect the high income elasticity of the U.S. feed demand.

The nonfeed U.S. coarse grain demand as specified by Equation (5) in Table 3.1 produced wrong signs; a negative sign for all variables. The perverse signs can likely be explained by the developments in the sugar market. Over the past decade, the high price of sugar, brought about an induced technological innovation to substitute corn fructose (a coarse grain product) for sugar. The combination of slowly but exponentially growing technology and the high sugar price account for the perverse signs.

Equation (19) in Table 4.1 specifies the U.S. nonfeed demand as a function of real coarse grain price, a lagged dependent variable, and a quadratic time trend variable. The equation has good statistical properties; all variables have the right sign and are significant with the exception of price (significant at the 10 percent level).

The presence of a lagged dependent variable in this equation, as well as others, could lead to autocorrelation. However, the Durbin h-statistics of these equations are not calculated for two reasons: (1) Johnston (1972) indicates that the h-statistic is only a large sample test (n>30) and nothing is known about its small-sample properties, and (2)

Taylor and Wilson (cited in Johnston, 1972) provide extensive evidence that even in inappropriate situations, the DW test is still a powerful detector of serial correlation problems.

In the light of past historical difficulty in estimating stock equations, the statistical properties of the U.S. inventory demand (20), in Table 4.1, are excellent. All explanatory variables have the correct sign and are significant at the .05 percent level. Estimated price elasticity is (-0.728), suggesting the presence of a speculative component in private demand for coarse grain.

The U.S. exchange rate is shown as Equation (20), Table 4.1. The equation is estimated in the double log form. Except for real income variables, the equation is identical to the grafted polynomial equation developed earlier in this chapter. The estimation of the original equation produced unexpected signs for the income variables and were consequently dropped from the specification. Almost 98 percent of the historical variation in the exchange rate is explained. The interest rate variables are highly significant. However, their elasticities are low and almost equal (0.4), in absolute value, for the period 1974-1980. The money supply variables remain in the equation despite their statistical insignificance. The money supply elasticities of the exchange rate are low and identical (0.68), in absolute value, for the period 1974-1980.

Japan's net coarse grain import demand is presented as Equation (23) in Table 4.1. Because Japan's coarse grain imports are corn dominated, and because barley imports are handled by the Japanese government, the corn price is taken to reflect the coarse grain price. The estimation of the original specification of the Japanese net coarse grain import demand, Equation (8), Table 3.1, produced statistically insignificant coefficients for current production and beginning inventory. This reflects Japan's extreme dependence on the international coarse grain market (100 percent of consumption). The statistical properties of the final specification are quite good with almost 97 percent of the variation explained; all variables have the correct sign at the 5 percent level.

The Japan price linkage Equation (24) in Table 5.2 meets the theoretical expectation given in Chapter III. The intercept is significant, reflecting the presence of the transportation cost and perhaps other additive factors such as specific taxes and subsidies in the world market. The slope is not significantly different from one. The estimated "price transmission elasticity" is 1.05, suggesting a perfect transmission of the changes in the world market condition.

The USSR net coarse grain import demand is shown as

Equation (25) in Table 4.1. The USSR grain consuming animal units (GCAU10) could not be located, and were therefore dropped from the original specification. The statistical properties of the estimated equation are good, in spite of the relatively low R-square. All coefficients are significant at the 5 percent level with the exception of current production (significant at the 10 percent level). The price elasticity (-1.106) confirms the CIA's 1979 report that with the USSR's growing import quantities and foreign exchange shortage, the demand is expected to be elastic. The income elasticity (7.161) reflects the rising real income and stable prices which influence the demand for meat by consumers in the USSR.

Equation (26) is the calculated price linkage of "the USSR coarse grain price". This specification affected the simulation results perversely as explained more fully in Appendix B. As a result, an alternative specification of the USSR price linkage was used to estimate and simulate the model. The details of the alternative specification are given in Appendix B.

Equations (27-30) report Argentina's trading behavior. The original net trade Equation (12) in Table 3.1 resulted in perverse statistical results. The major problem was the unavailability of the appropriate data. For example, data for national income, livestock price, and grain consuming animal units could not be found. In addition, with currency redefinitions (twice during the sample period, 1960-1980) and the compound rate of inflation around 67 percent for the same period, the quality of the available data is highly questionable.

Argentina's net coarse grain import demand is disaggregated to account for various Argentinian governmental policies affecting the corn and sorghum markets (the primary coarse grains). Equations (27) and (28) in Table 4.1 report the net export supply equations of corn and sorghum. The equations are statistically satisfactory. All coefficients are significant with the exception of sorghum price. The sorghum price is left in despite its lack of statistical significance because it does have the correct sign.

Equations (29) and (30) in Table 4.1 are the price suggest that Argentina permits world coarse grain market price adjustments to be reflected in its domestic coarse grain markets. The estimated elasticities in both equations are greater than one, suggesting a perfect price transmission of the world price.

The estimated Canadian net coarse grain export supply is given by Equation (31) in Table 4.1. Because the Canadian coarse grain market is barley dominated, the barley price is used as the coarse grain price. The grain consuming animal units (GCAU3) and the intercept were statistically insignificant and were therefore dropped. All other estimated parameters are significant at the 5 percent level. Although the Canadian export supply is elastic, the coarse grain production and livestock sector (livestock price) show greater influence on exports than the own price.

The estimated Canadian price linkage equation is shown in Equation (32), Table 4.1. The coefficient of the world price in Canadian dollars (E3JA.APCRN8) is significant at .01 percent. The elasticity, however, is smaller than one. This was expected because, as discussed in Chapter II, the Canadian Wheat Board (CWB) is the sole exporting agency for Canadian coarse grain. In addition, the CWB has also been the major domestic marketing agency for grains in general.

Equation (33) in Table 4.1 represents the estimated Australian net coarse grain exports. The price variable used is the trade weighted average of the unit export values of barley and sorghum. The estimation of the original specification, Equation (16) in Table 3.1, produced insignificant coefficients for soymeal and livestock prices and were therefore, dropped. The statistical properties of Equation (33) in Table 4.1 are good. All coefficients are significant at the 5 percent level except the price, which is significant at the 8 percent level. Again, the livestock sector appears to have more influence on trade than has the own price.

Equation (34) in Table 4.1 is the Australian price linkage equations. The slope is significant at the .01

percent level and is consistent with the expected world price transmission elasticity given in Chapter II. Domestic prices of Australian barley and sorghum move closely with the world price for reasons given in Chapter II.

The South African net coarse grain export equation is shown as Equation (36) in Table 4.1. Data for grain consuming animal units in South Africa are not available. Therefore, real income was used instead. Estimation of the original specification produced insignificant own and livestock price coefficients and was therefore, dropped. The final Equation (35) in Table 4.1 has good statistical properties. All coefficients are statistically significant at the 10 percent level. Current production appears to have influenced the trading behavior more than the other explanatory variables. This was expected for policy reasons given in Chapter II. The South African price linkage equation also had insignificant intercept and slope. Again, this was expected for the policy reasons given in Chapter II.

Equations (36) in Table 4.1 represents Thailand's net coarse grain export supply. The price variable used is the corn export price, Thailand's primary coarse grain. Because of the inavailability of data, real income is used in place of the grain consuming animal units. Estimation of the original specification, Equation (20) in Table 3.1, produced insignificant soymeal and livestock price coefficients and consequently, these variables were dropped. The final estimated Equation (36) in Table 4.1, includes a time trend variable. The statistical properties of this equation are quite good with almost 96 percent of historical variation in corn acreage explained; all variables have the correct sign and are significant at the .5 percent level with the exception of the price (significant at the 13 percent level). This is not surprising because over 70 percent of Thailand's coarse grain exports are covered by long-term contracts. Current coarse grain production and price elasticities are 1.00 and 0.266, respectively, suggesting that coarse grain exports are restricted more by the current production than by price.

Thailand's price linkage Equation (37) is reported in Table 4.1. The estimated price transmission coefficient is significant at the .01 percent level. The estimated "price transmission elasticity" is one, confirming the theoretical expectation. As was explained in Chapter II, the export prices have been based on the "world coarse grain price".

Validation of the Model

This section is concerned mainly with the performance and stability of the model. In general, there are no definite rules for measuring these two attributes of a model. The judgment on the performance of any model is largely subjective.

The "goodness" of the model can be determined by the validity of its estimates, its ability to reproduce the actual data in a dynamic simulation, and its stability. The estimated coefficients are reasonable when judged by economic theory and when compared to the estimated values of other studies. Most equations have a high R-square. Two out of 31 behavioral equations have positively correlated errors. They are the U.S. acreage harvested equations of two minor coarse grains, sorghum and barley, which are not the focus of this study. The remaining 29 consist of 17 equations with no serial correlation problems and 12 equations falling in the indeterminant range of the Durbin-Watson test. Given the size of the model, the validity of these estimates is satisfactory.

In order to measure the model's ability to replicate history, the model is simulated over the period (1962-1980), given the first year data (1962). The simulation result is then compared to the observed data.

The statistics measuring the model's simulation performance include residual mean square (RMS) error, RMS percent error, and Theil's forecast statistics.

The RMS error of a variable is defined as follows:

$$\text{RMS} = \sqrt{\frac{1}{n} \sum_{t=1}^{n} (\hat{Y}_t - Y_t)^2}$$

$$= \sqrt{\frac{1}{n} \cdot \sum_{y=1}^{n} [(\hat{Y}_t - Y_t) - (Y_t - Y_{t-1})]^2}$$

where

$\hat{Y}_t$ = simulation estimate of observation in time t;

Y_t = actual value of observation in time t;

n = number of observations

This statistic measures the average error of the simulated values from the actual values. The period by period deviation of the simulation variable from its actual time path can be measured by RMS error. The size of RMS error is dependent upon the variable size and is thus difficult to interpret. To eliminate this problem, RMS percent error is often used instead. It is defined as follows:

$$\text{RMS percent error} = \sqrt{\frac{1}{n} \sum_{t=1}^{n} \left(\frac{\hat{Y}_t - Y_t}{Y_t}\right)^2} .$$

Theil's statistics are also often used to measure simulation performance of a model. There are 3 different components: UM (bias error), UR (regression error), and UD (disturbance error). These components are derived from the following model, suggested by Cohen and Cyert (1961):

$$Y_t = a + b\hat{Y}_t + U_t$$

where Y_t and $\hat{Y}_t$ are defined as before and U_t is a random error term distributed normally and identically with zero mean and constant variance.

If $a = 0$ and $b = 1$, then the forecast will be unbiased since $E(Y_t) = E(\hat{Y}_t)$.

The forecast will be biased if it underestimates or overestimates its corresponding actual values systematically. This will occur if either $a \neq 0$ or $b \neq 1$.

If $a = 0$ and $b = 1$, the forecast will be both unbiased and efficient, in the mean square error sense. The mean square error can be decomposed as follows:

$$MSE = \frac{1}{n} \cdot \sum_{t=1}^{n} (Y_t - \hat{Y}_t)^2$$

$$= (\overline{Y} - \overline{\hat{Y}})^2 + (b-1) \cdot \frac{1}{n} \sum_{t=1}^{n} (\hat{Y}_t - \overline{\hat{Y}}_t)^2$$

$$= \frac{1}{n} \sum_{t=1}^{n} U_t^{\,2}$$

$$= UM + UR + UD.$$

Where $\overline{Y}$ and $\overline{\hat{Y}}$ are the means of the observed and simulated values.

Therefore, if a = 0 and b = 1, then MSE $= \frac{1}{n} \sum_{t=1}^{n} U_t^2$, which is the smallest possible MSE.

Table 4.3 presents RMS errors and RMS percent error. Table 4.4 presents Theil's forecast statistics. Most endogenous variables have reasonable RMS percent errors less than 0.20. Out of 41 endogenous variables, the 19 following variables have high RMS errors; these are: CWP1, USAPPROO, USAPPRSS, USAPPRBB, LFPCRN1, NXT1, WPCRN8, NMT8, PRICE10, MMT10, NPRCRN2, NPRSGM2, NXTCRN2, NXTSGM2, BARWP3, NXT3, CGP4, NXTY, NXT5. The RMS percent error statistics portray the nature of the world coarse grain market unequivocally. As the estimated elasticities reported earlier in this chapter indicate, the world excess coarse grain demand is fairly inelastic. This was, of course, expected for the policy reasons given in Chapter II: the major coarse grain importing nations of the world are made up of developed nations which are highly protective of their markets. For this reason, any small simulation error results in large price volatility, which is then transmitted more to the domestic markets of the regions with larger price elasticities.

This portion of the RMS errors can be eliminated through a number of techniques. One technique applied by Huyser (1983) in her world soybean and soymeal model is to force in a price elasticity for the rest of world

Table 4.3. Residual mean errors of the base simulation

Variable[a]	Statistics of Fit: RMS Error	Statistics of Fit: RMS % Error
NXT5	554624	0.658668
USAPPROO	17.6725	0.396815
USAPPRBB	25.7109	0.884919
USAPPRSS	21.7876	0.798556
LFPCRN1	18.1216	0.390464
LE8US	0.0280084	0.00494501
APCAT1	2736299	0.12125
APBAR1	2329748	0.216666
APSOR1	1944880	0.114925
APCRN1	2881431	0.0432271
LOGPR	0.137307	0.0314444
E8US	8.23531	0.0281292
AHOAT1	2348596	0.143724
AHBAR1	1845984	0.190406
AHSOR1	1827758	0.143489
AHCRN1	2792126	0.0491542
PRGOLD78	13.5654	0.128336
QPOAT1	1655133	0.143724
QPBAR1	1631700	0.190406
QPSOR1	2299395	0.143489
QPCRN1	5246444	0.0491542
QP1	9785109	0.0701836
NFD1	445181	0.0352425
CWP1	19.4486	0.382534
WPCRN8	8169.04	0.350001
NMT8	1683168	0.30908
EI1	8623471	0.19881
NMT10	4589297	3.53681
NPRCRN2	1025223	23.8776
PRICE10	0.538422	0.409532
NXTCRN2	28322600	9.28922
NXTSGM2	16645045	50.3525
BARWP3	21.79	0.399239
NXT3	1174261	2.21407
CGP4	24.5984	0.494626
NXT4	860486	1.06359
NPRSGM2	1145988	33.1528
EXPRCRN6	500.674	0.401793
NXT6	184626	0.17654
NXT1	38724845	2.00063
FD1	23807203	0.216878

[a]See Table 4.2 for variable name definitions.

Table 4.4. Theil's forecast error measures

Variable[a]	Relative change MSE	Decomposition			
		Bias (UM)	Regress (UR)	Disturb. (UD)	Accuracy (U1)
NXT5	0.179429	0.10	0.33	0.57	0.0000
USAPPROO	0.152319	0.43	0.39	0.18	0.0058
USAPPRBB	0.736089	0.36	0.53	0.11	0.0122
USAPPRSS	0.604789	0.37	0.53	0.09	0.0129
LFPCRN1	0.152308	0.38	0.39	0.23	0.0055
LE8US	0.0000241	0.00	0.00	1.00	0.0009
APOAT1	0.0127039	0.32	0.38	0.30	0.0000
APBAR1	0.0400029	0.33	0.46	0.21	0.0000
APSOR1	0.0129449	0.32	0.30	0.38	0.0000
APCRN1	0.00176206	0.31	0.02	0.67	0.0000
LOGPR	0.00123409	0.00	0.01	0.99	0.0078
E8US	0.00073163	0.00	0.00	1.00	0.0001
AHOAT1	0.0177643	0.30	0.35	0.35	0.0000
AHBAR1	0.031793	0.32	0.42	0.25	0.0000
AHSOR1	0.0196536	0.23	0.40	0.38	0.0000
AHCRN1	0.00223517	0.27	0.06	0.67	0.0000
PRGOLD78	0.049749	0.00	0.00	0.99	0.0011
QPOAT1	0.0187504	0.28	0.14	0.58	0.0000
QPBAR1	0.0350005	0.31	0.39	0.30	0.0000
QPSOR1	0.0216157	0.22	0.33	0.45	0.0000
QPCRN1	0.00233992	0.27	0.01	0.72	0.0000
QP1	0.00473162	0.32	0.07	0.61	0.0000
NFD1	0.0013021	0.39	0.37	0.25	0.0000
CWP1	0.147124	0.37	0.41	0.22	0.0047
WPCRN8	0.136865	0.39	0.39	0.21	0.0000
NMT8	0.203207	0.19	0.76	0.05	0.0000
EI1	0.0387473	0.17	0.20	0.62	0.0000
NMT10	6.0582	0.43	0.33	0.24	0.0000
NPRCRN2	812.306	0.45	0.52	0.03	0.0000
PRICE10	0.158009	0.33	0.46	0.21	0.3599
NXTCRN2	89.4151	0.37	0.63	0.00	0.0000
NXTSGM2	2274.59	0.27	0.72	0.00	0.0000
BARWP3	0.148538	0.36	0.42	0.22	0.0044
NXT3	392.407	0.05	0.95	0.00	0.0000
CGP4	0.250498	0.36	0.40	0.24	0.0069
NXT4	1.54449	0.39	0.51	0.11	0.0000
NPRSGM2	1499.05	0.45	0.54	0.01	0.0000
EXPRCRN6	0.17802	0.40	0.41	0.19	0.0002
NXT6	0.0394524	0.19	0.12	0.68	0.0000
NXT1	4.80075	0.39	0.60	0.01	0.0000
FD1	0.047031	0.38	0.49	0.13	0.0000

[a]See Table 4.2 for variable name definitions.

import demand equations. However, it is not clear that this procedure would reflect the true structure of the world coarse grain market.

In addition, variables with small absolute values produce a high proportion of errors for any small changes in value. All Argentina variables, for example, have large RMS percent error because of their relatively small magnitudes and the contrast in the magnitude of variables during the beginning and the end of the studied period.

Theil's forecast errors of simulation variables are presented in Table 4.4. The statistics are weighted so that all the three components of MSE sum to 1.0. The same variables which have high RMS percent errors (mentioned earlier), have high URs also. The same explanation, as in the case when they have high RMS percent errors, is also applied here. In addition, the fact that the livestock sector is exogenous may contribute to the size of the RMS percent errors, because coarse grain is primarily used by livestock producers. The importance of the livestock sector is evident from the elasticities and the statistical significance of the exogenous livestock related variables reported in the previous section.

Another measure of model performance is the extent to which turning points are correctly simulated. Evidence of this model's turning point accuracy can be seen by looking at the key price series. The major international prices are the U.S. and Japan prices, and the U.S. exchange rate.

For the U.S. price, there are three turning point errors from the 19 year dynamic simulation, which occur in the first three years (Figure 4.1). For the Japan price there are four turning point errors which occur again in the first four years (Figure 4.2). For the U.S. exchange rate, there are four turning points again, in the first 9 years (Figure 4.3).

The comparison of simulated values and the actual data is satisfactory. The model has a good ability to trace upward and downward movements in the data. The estimates are closer to the 1970s actual data than the 1960s. In the case where data show extreme fluctuations over time, the simulation results tend to be more accurate in later years than in the beginning of the period.

The stability of the model is measured by its response to a one period exogenous shock. If the fluctuation response to the shock is decreasing as time passes, and the simulation estimates move back to the base simulated results over time, the model is stable. The faster the adjustment back toward the base simulated results, the more stable the model. This model's stability is tested by the

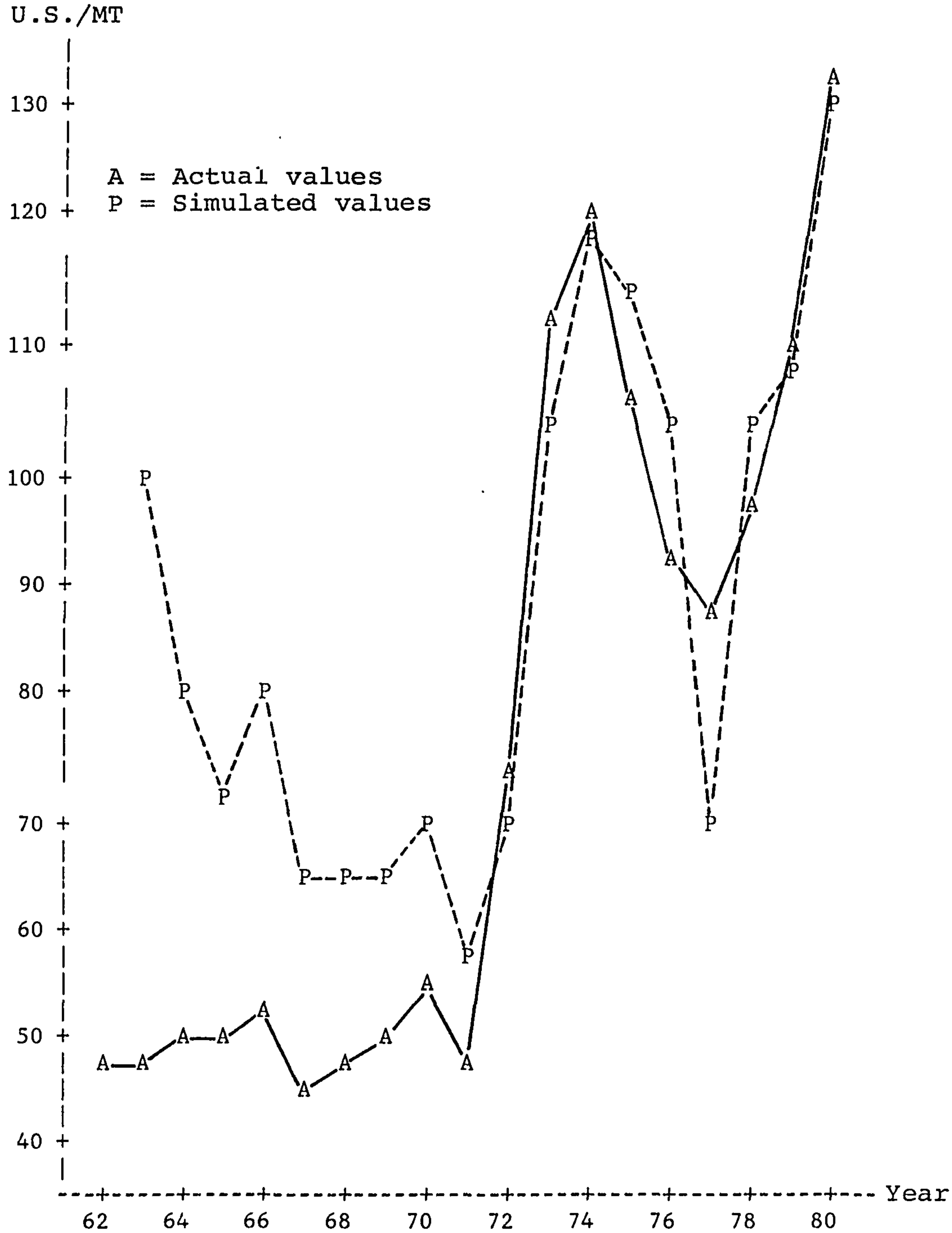

Figure 4.1. Comparison of actual and simulated U.S. coarse grain prices

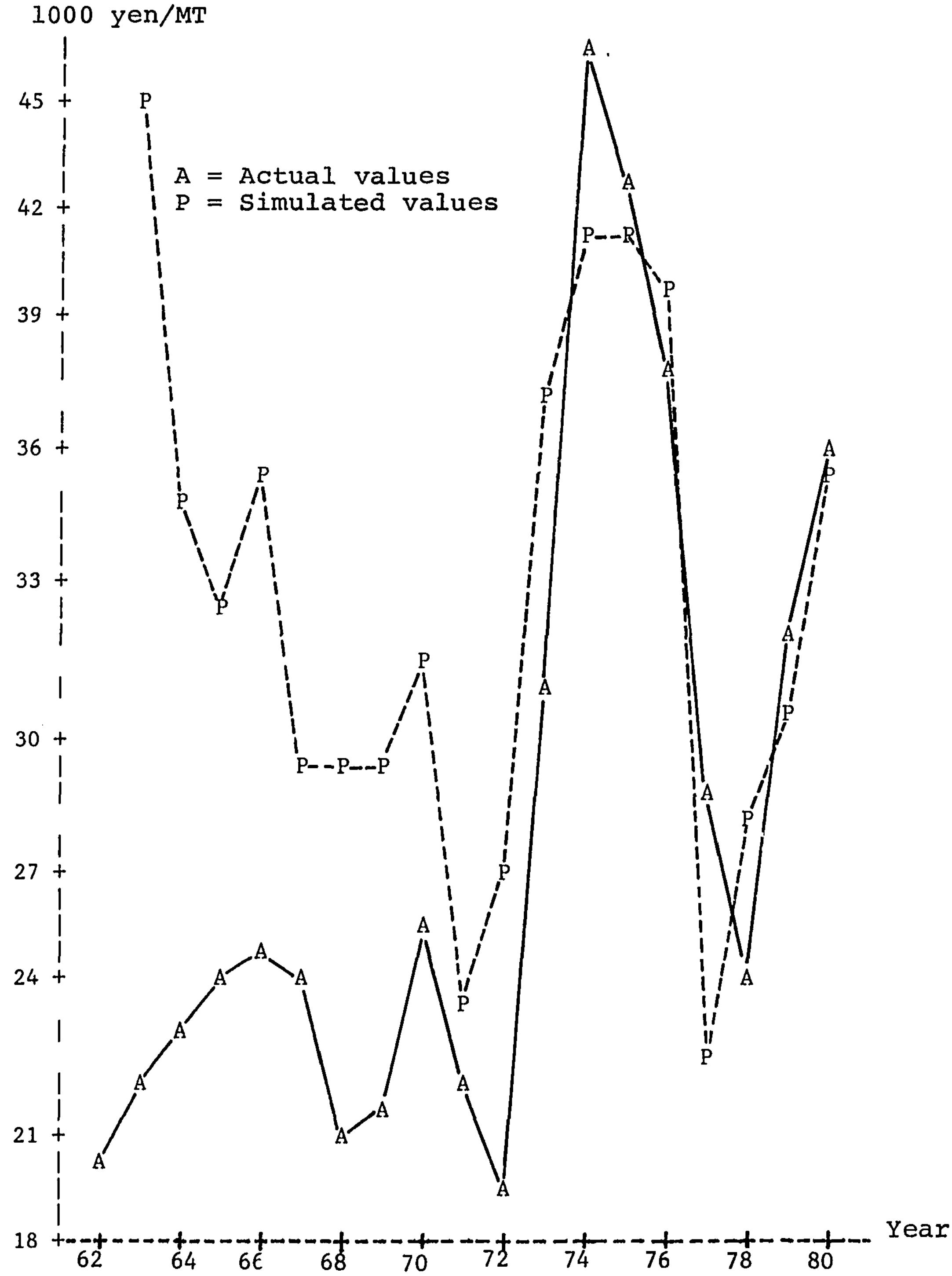

Figure 4.2. Comparison of actual and simulated Japan coarse grain prices

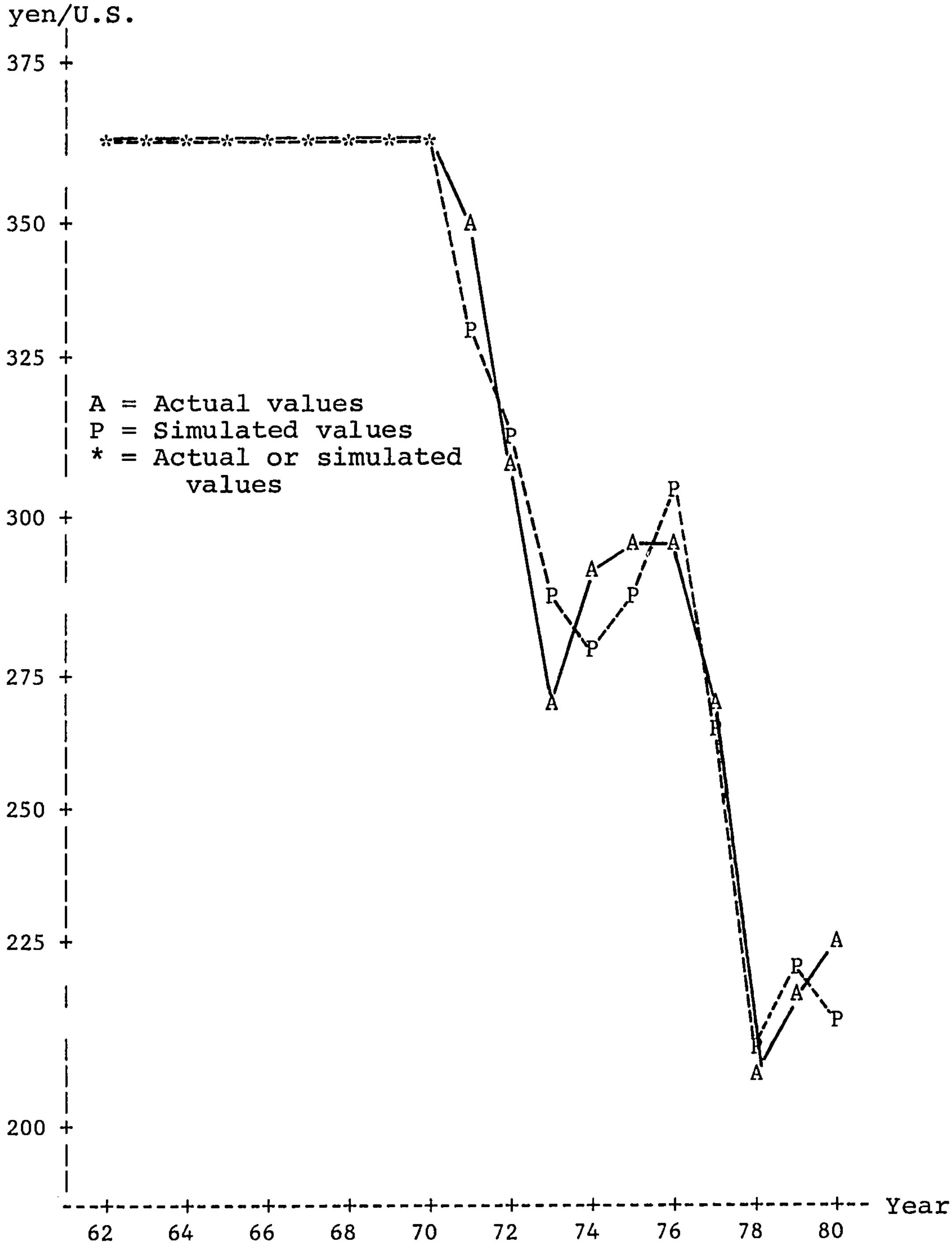

Figure 4.3. Comparison of actual and simulated U.S. exchange rates

results of a hypothetical increase in the U.S. money supply in 1971. Given this shock, the simulation is rerun for the period of 1971 to 1980. The U.S. money supply is assumed to increase by 5 billion dollars. This increase amounts to roughly 1 percent of the U.S. money stock in 1971. The expected immediate effect of this increase is a decrease in the U.S. exchange rate. The depreciation of the dollar would then increase the foreign demand for the U.S. coarse grain. This would then improve the competitive position of the U.S. in the world market. That is, while the U.S. coarse grain exports increase, the exports of the other exporters decrease. As a result, the U.S. coarse grain price would increase, which in turn would cause a reduction in the U.S. domestic coarse grain disappearance. The U.S. dollar depreciation works as a subsidy, creating a wedge between the domestic prices of the U.S. and other exporters. This would increase the U.S. share of the export market. As a result of a reduction in the other exporters' market share, the domestic coarse grain supply in those regions would increase pushing their domestic prices down. However, the dynamic effects in the following years on all variables depend upon the relative supply and demand responses to the changes in the coarse grain prices of all the trading regions.

Table 4.5 reports the dynamic simulation results. As expected, the increase in the U.S. money supply causes the U.S. dollar to depreciate by .11 percent from the base solution in 1971. Both U.S. coarse grain exports and prices increase, leading to higher export revenues. However, the percent increase in export is larger than the percent increase in price. This implies that U.S. coarse grain export supply is price elastic to trading countries. U.S. coarse grain feed, nonfeed, and inventory demands decrease as the price increases. The inventory demand bears an important share of the adjustment because of its relatively higher price elasticity. The U.S. coarse grain production increases as well over time. The shock affects the following year's planting decision because acreage decisions are a one year lag process.

Imports of Japan and the USSR increase while their prices decrease. However, in percentage terms, the USSR reacts more to the shock than Japan does. Interestingly, the cost of imports to the USSR increases while it decreases for Japan. This is because the percent increase in imports relative to percent decrease in price is higher for the USSR, while it is lower for Japan.

The response of the other exporters' market conditions

Table 4.5. Dynamic impact of a one period increase in U.S. money supply

Year	Base	Change	% Change	Base	Change	% Change
U.S. Exchange rate (yen/US $)				U.S. Coarse grain price (U.S. $/MT)		
71	330.2	-0.38	-0.11	64.67	0.023	0.03
72	308.6	-0.63	-0.20	77.36	0.037	0.04
73	291.7	-0.83	-0.28	106.97	0.066	0.06
74	278.5	-1.01	-0.36	126.37	0.058	0.04
75	289.9	-0.93	-0.32	111.80	0.057	0.05
76	306.4	-0.86	-0.28	104.41	0.050	0.04
77	262.5	-0.67	-0.25	56.07	0.055	0.09
78	213.4	-0.50	-0.23	110.36	0.028	0.02
79	223.7	-0.49	-0.22	111.21	0.022	0.02
80	221.6	-0.44	-0.20	133.30	0.027	0.02
U.S. Coarse grain exports (1000 MT)				U.S. Coarse grain nonfeed consumption (1000 MT)		
71	73784	34.30	0.04	12180	-0.34	-0.002
72	58510	64.38	0.11	12936	-0.70	-0.005
73	47407	103.25	0.21	13546	-1.19	-0.008
74	54283	86.31	0.15	14243	-1.34	-0.009
75	62035	77.90	0.12	15277	-1.41	-0.009
76	47730	67.14	0.14	16499	-1.35	-0.008
77	33413	67.63	0.20	18225	-1.33	-0.007
78	57231	42.59	0.07	19490	-1.07	-0.005
79	67528	27.08	0.04	20963	-0.83	-0.003
80	66899	24.88	0.03	22451	-0.69	-0.003

Table 4.5 (Continued)

Year	Base	Change	% Change	Base	Change	% Change
	U.S. Coarse grain nonfeed demand (1000 MT)			U.S. Coarse grain production (1000 MT)		
71	106941	-25	-0.024	206079	00.0	0.000
72	132061	-39	-0.030	189987	13.6	0.007
73	142025	-66	-0.046	195406	17.0	0.008
74	89297	-53	-0.059	149058	17.9	0.012
75	103755	-47	-0.046	192891	16.0	0.008
76	114722	-39	-0.034	192620	15.9	0.008
77	138810	-40	-0.029	206636	14.9	0.007
78	130026	-19	-0.015	203793	18.8	0.009
79	146807	-14	-0.009	240525	9.1	0.003
80	117290	-14	-0.012	196399	5.5	0.002
	U.S. Coarse grain inventory (100 MT)			Japan coarse grain price (Yen/MT)		
71	43489	-8.17	-0.018	26637.6	-21.12	-0.07
72	30683	-10.33	-0.033	29769.0	-46.50	-0.15
73	21878	-18.32	-0.083	38871.7	-87.35	-0.22
74	11674	-13.90	-0.119	43815.3	-138.38	-0.31
75	25668	-12.54	-0.048	40361.9	-109.07	-0.27
76	29077	-10.00	-0.034	39845.5	-93.43	-0.23
77	45074	-10.50	-0.023	18397.5	-28.84	-0.15
78	37312	-3.09	-0.008	29361.5	-62.00	-0.21
79	50348	-2.95	-0.005	31005.5	-61.78	-0.19
80	41148	-3.79	-0.009	36799.1	-66.82	-0.18

Table 4.5 (Continued)

Year	Base	Change	% Change	Base	Change	% Change
	USSR Coarse grain price (ounces/MT)			USSR Coarse grain import (1000 MT)		
71	1.40	-0.003	-0.25	2152	21.9	1.01
72	1.28	-0.006	-0.48	3352	37.3	1.11
73	1.48	-0.009	-0.67	-880	59.9	6.80
74	0.63	-0.005	-0.88	5636	33.3	0.59
75	0.68	-0.005	-0.77	12234	31.8	0.26
76	0.86	-0.005	-0.67	2789	35.2	1.26
77	0.32	-0.001	-0.55	11210	10.7	0.09
78	0.49	-0.002	-0.58	8038	17.2	0.21
79	0.21	-0.001	-0.54	14443	6.8	0.04
80	0.22	-0.001	-0.49	14890	6.8	0.04
	Argentina corn price (pesos/MT)			Japan coarse grain import (1000 MT)		
71	-298997	-34	-0.01	9653	3.4	0.03
72	-260622	-126	-0.04	9775	7.3	0.07
73	-220772	-271	-0.12	13400	12.1	0.09
74	-216022	-396	-0.18	13423	14.6	0.10
75	121667	-1252	-1.02	12810	11.2	0.08
76	1479346	-4270	-0.28	14114	9.1	0.06
77	2334380	-4195	-0.17	17533	2.7	0.01
78	9572061	-20934	-0.21	17069	6.1	0.03
79	15776383	-32117	-0.20	19008	5.7	0.03
80	25258036	-46481	-0.18	19993	5.2	0.02

Table 4.5 (Continued)

Year	Base	Change	% Change	Base	Change	% Change
Argentina sorghum price (pesos/MT)[a]				Argentina corn exports (1000 MT)[a]		
71	-304451	-29	-0.00	-38044	-4.5	-0.01
72	-271495	-108	-0.03	-19893	-9.7	-0.04
73	-237272	-233	-0.09	-9116	-13.9	-0.15
74	-233193	-340	-0.14	-6294	-16.9	-0.26
75	56810	-1075	-1.89	3512	-18.3	-0.52
76	1222769	-3667	-0.29	4064	-10.4	-0.25
77	1957061	-3603	-0.18	26452	-43.6	-0.16
78	8172692	-17978	-0.22	7218	-8.3	-0.11
79	13500887	-27582	-0.20	5653	-5.1	-0.09
80	21643615	-39917	-0.18	3769	-4.2	-0.11
Argentina sorghum exports (1000 MT)[a]				Canada coarse grain price (Can $/MT)[a]		
71	-5479	-0.71	-0.01	63.28	-0.04	-0.07
72	-3131	-1.52	-0.04	78.98	-0.11	-0.14
73	-124	-2.17	-1.74	114.64	-0.24	-0.21
74	1162	-2.65	-0.22	117.47	-0.36	-0.30
75	2316	-2.86	-0.12	110.93	-0.29	-0.26
76	3148	-1.63	-0.05	106.41	-0.24	-0.22
77	7265	-6.82	-0.09	60.06	-0.08	-0.14
78	4380	-1.30	-0.02	127.14	-0.26	-0.20
79	3912	-0.80	-0.02	132.25	-0.25	-0.19
80	1254	-0.66	-0.05	150.94	-0.26	-0.17

[a]Repeated attempts were made to detect the cause of the negative numbers in these tables and the high RMs (reported earlier) for Argentina. One likely cause is the SAS programming regression precision versus the simulation precision. For simulation, the observed Argentinean exchange rate might have been read as zero for the period 1960-1973, since its magnitude was on the order of 10^{-7}. However, because of Argentinean hyper-inflation, the exchange rate grew very rapidly eliminating the problem for the 1974-80 period.

Table 4.5 (Continued)

Year	Base	Change	% Change	Base	Change	% Change
Canada coarse grain export (1000 MT)				South Africa coarse grain export (1000 MT)		
71	5627	-1.9	-0.03	2883	0	0
72	3927	-4.5	-0.11	3178	0	0
73	2016	-8.8	-0.43	3866	0	0
74	1822	-11.0	-0.60	2800	0	0
75	2459	-8.0	-0.32	1708	0	0
76	3426	-6.0	-0.17	3006	0	0
77	3588	-2.0	-0.05	3442	0	0
78	3636	-5.7	-0.15	2307	0	0
79	3311	-5.1	-0.15	3653	0	0
80	4017	-4.8	-0.12	5286	0	0
Australia coarse grain price (Aus. $/MT)				Australia coarse grain exports (1000 MT)		
71	54.92	-0.04	-0.09	3101	-1.3	-0.04
72	68.98	-0.11	-0.17	2577	-2.9	-0.11
73	85.91	-0.21	-0.24	2786	-4.5	-0.16
74	89.21	-0.30	-0.34	2696	-5.6	-0.21
75	88.92	-0.26	-0.29	2851	-4.1	-0.14
76	94.37	-0.23	-0.25	2801	-3.3	-0.11
77	49.86	-0.09	-0.18	1797	-1.1	-0.06
78	105.73	-0.23	-0.22	3033	-2.8	-0.09
79	110.07	-0.23	-0.21	3100	-2.5	-0.08
80	124.83	-0.24	-0.19	2283	-2.3	-0.10

Table 4.5 (Continued)

Year	Base	Change	% Change	Base	Change	% Chang
	Thailand coarse grain price (baht/MT)			Thailand coarse grain exports (1000 MT)		
71	1433.54	-1.21	-0.08	2215	-0.3	-0.01
72	1875.72	-3.09	-0.16	1560	-0.9	-0.05
73	2755.23	-6.42	-0.23	2331	-1.6	-0.07
74	2858.41	-9.35	-0.32	2300	-1.9	-0.08
75	2582.16	-7.25	-0.28	2549	-1.4	-0.05
76	2552.64	-6.22	-0.24	2390	-1.1	-0.04
77	1251.02	-2.12	-0.16	1250	-0.3	-0.02
78	2646.13	-5.80	-0.21	2071	-0.9	-0.04
79	2696.09	-5.57	-0.20	2281	-0.8	-0.03
80	3116.95	-5.84	-0.18	2283	-0.7	-0.03

is as expected. Both exports and prices decrease in all export competing regions.

The immediate effect of an increase in the U.S. money supply agrees with the *a priori* expectations for all countries. The highest percent change of all variables occurs in or immediately following the year of the adoption of flexible exchange rate (1973). The shock affects the U.S. coarse grain production a year later. This is because the acreage planted decisions are made on the basis of the lagged prices. The percentage change of all variables is decreasing as time passes. Some variables are more stable than others and move faster toward their equilibrium levels. The results of this model show responses to the exogenous shock in the expected directions. The model is stable since after the shock, all variables move back to their base values over time.

Overall, this model's performance is satisfactory. All behavioral equations have good predictability. The relationships among all variables agree with prior economic expectations. The dynamic historical simulation has reasonably good statistical properties, and the model is also stable and adjusts toward equilibrium after an exogenous shock.

CHAPTER V. DYNAMIC U.S. MONEY SUPPLY SIMULATION

Models are often constructed and utilized to predict how a change in one variable is likely to affect other variables over time. One objective of this research is to better understand and quantify the interrelationship among the world's major coarse grain trade participants in order to evaluate the impacts of alternative events or policies on these markets. Of particular interest to this study is the relationship between the U.S. and world agricultural markets and the U.S. monetary sector. In this chapter, the effect of growth in the U.S. money supply on the world coarse grain market is analyzed through dynamic simulation of the world coarse grain market model discussed in the previous chapter.

In this simulation, it did not seem reasonable to assume that the monetary authority would alter money supply growth in only one year. It is therefore assumed that the monetary authority increases the money growth target resulting in a once and for all increase in the money supply rather than a single year increase in the money supply. This results in a compounding effect. That is, the consequent changes in the exchange rate, trade prices, and the other endogenous variables in any period will include the dynamic effects of the increase in the money supply of all previous periods.

Before presenting the rate of growth of the actual and altered levels of the money supply, it should be emphasized, as discussed in Chapter I, that changes in money supply before the demise of the Bretton-Woods system had little effect on the value of the U.S. dollar. Therefore, the simulation is performed only for the decade of the 1970s. Table 5.1 compares the actual and simulated annual and average compound rates of growth of the U.S. money supply. The simulated increase in the money supply assumes that the U.S. monetary authority allows the money supply to grow by five billion dollars a year in the manner explained above.

Table 5.1. Actual and altered growth rate of U.S. money supply

Year	Annual Growth Rate (%)		
	Actual	Altered	Difference
71	13.5	14.3	.8
72	13.0	13.6	.6
73	6.9	7.5	.6
74	5.5	6.0	.5
75	12.6	12.9	.3
76	13.7	13.9	.2
77	10.6	10.7	.1
78	8.0	8.1	.1
79	7.9	8.0	.1
80	8.9	9.0	.1
Compound growth rate	9.6	9.9	.3

The expansionary effect of the simulated increase in the money supply tends to depreciate the U.S. dollar as explained in previous chapters. This depreciation acts as an implicit subsidy making U.S. coarse grain more price competitive in international markets. The associated increase in the quantity demanded of U.S. coarse grains by importing countries leads to a general rise in the U.S. coarse grain price, which in turn brings about an increase in U.S. coarse grain production over time as well as a decrease in the U.S. domestic coarse grain disappearance in each year. A consequent reduction in demand for the coarse grain of the other exporting regions leads to a general decrease in their domestic prices.

Simulation of the model as described in Chapter III produced perverse results for the USSR, due to initial misspecification of the price linkage equation for the USSR. The USSR coarse grain price was originally calculated in the model as the U.S. coarse grain price in terms of gold. Given an exogenous gold value of the dollar, this price linkage specification required the "USSR coarse grain price" to increase along with the U.S. price as a result of an expansionary U.S. monetary policy. As a consequence, USSR coarse grain imports declined as the U.S. currency depreciated in value. To avoid this problem, the gold-dollar exchange rate was subsequently endogenized and an alternative USSR price linkage equation was specified (see Appendix B for the modified specifications and the estimated results).

Table 5.2 reports the results of the simulation. As expected, the expansionary U.S. monetary policy exacerbates a situation of excess supply in the money market which depreciates the U.S. currency and, thus, increases the demand for the U.S. coarse grain on the international market. The exchange rate depreciates continually, falling by 35.1 yen/$ (10.6 percent) between 1971-1980. U.S. exports increase more rapidly with the adoption of flexible exchange rates in 1973 than in the late 1970s, corresponding to the nature of the simulated growth in the U.S. money supply. Table 5.1 indicates that the U.S. money supply is increased at a faster rate in the early than the late 1970s. The U.S. feed, nonfeed, and inventory demands respond in a similar pattern to the U.S. exports, but in the opposite direction. The simulated increase in U.S. coarse grain production is smaller than the increase in the U.S. coarse grain import demand, pushing up the U.S. coarse grain price on average over the period.

The increase in U.S. coarse grain exports is absorbed by increases in imports by Japan and the USSR. However, the USSR reacts more dramatically than Japan, because of the higher estimated USSR price elasticity of import demand.

The world coarse grain market is characterized by

Table 5.2. Dynamic impact of a sustained linear increase of the U.S. money supply

Year	Base	Change	% Change	Base	Change	% Change
U.S. exchange rate (yen/$)				U.S. coarse grain price (U.S. $/MT)		
71	330.27	-0.38	-0.11	64.67	0.023	0.03
72	308.69	-1.25	-0.40	77.36	0.080	0.10
73	291.79	-2.49	-0.85	106.97	0.204	0.19
74	278.51	-3.98	-1.43	126.37	0.241	0.19
75	289.92	-4.60	-1.58	111.80	0.293	0.26
76	306.47	-5.12	-1.67	104.41	0.309	0.29
77	262.55	-4.62	-1.76	56.07	0.390	0.69
78	213.43	-3.97	-1.86	110.36	0.237	0.21
79	223.70	-4.34	-1.94	111.21	0.208	0.18
80	221.63	-4.39	-1.98	133.30	0.274	0.20
U.S. nonfeed coarse grain demand (1000 MT)				U.S. coarse grain exports (1000 MT)		
71	12180	-0.34	-0.00	73784	34	0.04
72	12936	-1.28	-0.00	58510	126	0.21
73	13546	-3.12	-0.02	47407	304	0.64
74	14243	-4.38	-0.03	54283	338	0.62
75	15277	-5.58	-0.03	62035	381	0.61
76	16499	-6.34	-0.03	47730	392	0.82
77	18225	-7.32	-0.04	33413	461	1.38
78	19490	-6.47	-0.03	57231	330	0.57
79	20963	-5.51	-0.02	67528	237	0.35
80	22451	-5.15	-0.02	66899	242	0.36

Table 5.2 (Continued)

Year	Base	Change	% Change	Base	Change	% Change
	U.S. feed coarse grain demand (1000 MT)			U.S. coarse grain production (1000 MT)		
71	106941	-25.7	-0.02	206079	00.00	0.00
72	132061	-86.0	-0.06	189987	13.66	0.00
73	142025	-205.5	-0.14	195406	37.06	0.01
74	89297	-218.6	-0.24	149058	55.22	0.03
75	103755	-243.2	-0.23	192891	65.99	0.03
76	114722	-242.1	-0.21	192620	80.99	0.04
77	138810	-287.3	-0.20	206636	90.74	0.04
78	130026	-162.1	-0.12	203793	132.70	0.06
79	146807	-127.8	-0.08	240525	76.19	0.03
80	117290	-148.2	-0.12	196399	50.17	0.02
	U.S. coarse grain inventory (1000 MT)			Japan coarse grain price (yen/MT)		
71	43489	-8.1	-0.01	26637.6	-21.12	-0.07
72	30683	-25.0	-0.08	29769.0	-90.15	-0.30
73	21878	-59.0	-0.27	38871.7	-257.61	-0.66
74	11674	-60.2	-0.51	43815.3	-543.58	-1.24
75	25668	-66.2	-0.25	40361.9	-534.75	-1.32
76	29077	-63.4	-0.21	39845.5	-548.85	-1.37
77	45074	-76.1	-0.16	18397.5	-197.00	-1.07
78	37312	-29.5	-0.07	29361.5	-483.46	-1.64
79	50348	-27.9	-0.05	31005.5	-543.38	-1.75
80	41148	-38.7	-0.09	36799.1	-653.02	-1.77

Table 5.2 (Continued)

Year	Base	Change	% Change	Base	Change	% Change
Gold price ($/ounce)				USSR coarse grain price (ounces of gold/MT)		
71	46.097	0.13	0.29	1.40	-0.00	-0.2600
72	59.953	0.63	1.05	1.28	-0.01	-0.9501
73	72.210	1.60	2.22	1.48	-0.02	-1.9859
74	200.529	7.54	3.76	0.63	-0.02	-3.4445
75	163.416	6.83	4.18	0.68	-0.02	-3.7778
76	120.169	5.30	4.41	0.86	-0.03	-3.9383
77	174.476	8.12	4.65	0.32	-0.01	-3.7921
78	224.310	11.07	4.93	0.49	-0.02	-4.4990
79	527.257	27.15	5.15	0.21	-0.00	-4.7217
80	583.672	30.69	5.25	0.22	-0.01	-4.8004
USSR coarse grain imports (1000 MT)				Japan coarse grain imports (1000 MT)		
71	2152	21.9	1.01	9653	3.4	0.03
72	3352	73.6	2.19	9775	14.3	0.14
73	-880	176.9	20.10	13400	35.9	0.26
74	5636	130.5	2.31	13423	57.7	0.43
75	12234	155.4	1.27	12810	55.1	0.43
76	2789	205.7	7.37	14114	53.9	0.38
77	11210	73.3	0.65	17533	19.0	0.10
78	8038	133.1	1.65	17069	47.8	0.28
79	14443	59.9	0.41	19008	50.3	0.26
80	14890	65.9	0.44	19993	51.1	0.25

Table 5.2 (Continued)

Year	Base	Change	% Change	Base	Change	% Change
Argentina corn price (pesos/MT)				Argentina sorghum price (pesos/MT)		
71	-298997	-34	-0.01	-304451	-29	-0.00
72	-260622	-245	-0.09	-271495	-210	-0.07
73	-220772	-800	-0.36	-237272	-687	-0.28
74	-216022	-1556	-0.72	-233193	-1337	-0.57
75	121667	-6136	-5.04	56810	-5270	-9.27
76	1479346	-25081	-1.69	1222769	-21538	-1.76
77	2334380	-28653	-1.22	1957061	-24606	-1.25
78	9572061	-163233	-1.70	8172692	-140182	-1.71
79	15776383	-282470	-1.79	13500887	-242581	-1.79
80	25258036	-454279	-1.79	21643615	-390129	-1.80
Argentina sorghum exports (1000 MT)				Argentina corn exports (1000 MT)		
71	-5479	-0.71	-0.01	-38044	-4.5	-0.01
72	-3131	-2.95	-0.09	-19893	-18.8	-0.09
73	-124	-6.42	-5.15	-9116	-41.0	-0.45
74	1162	-10.41	-0.89	-6294	-66.5	-1.05
75	2316	-14.03	-0.60	3512	-89.7	-2.55
76	3148	-9.57	-0.30	4064	-61.2	-1.50
77	7265	-46.59	-0.64	26452	-297.9	-1.12
78	4380	-10.15	-0.23	7218	-64.9	-0.89
79	3912	-7.05	-0.18	5653	-45.0	-0.79
80	1254	-6.46	-0.51	3769	-41.3	-1.09

Table 5.2 (Continued)

Year	Base	Change	% Change	Base	Change	% Change
Canada coarse grain price (Can $/MT)				Canada coarse grain exports (1000 MT)		
71	63.28	-0.04	-0.07	5627	-1.9	-0.03
72	78.98	-0.22	-0.28	3927	-8.8	-0.22
73	114.64	-0.73	-0.64	2016	-25.9	-1.28
74	117.47	-1.41	-1.20	1822	-43.2	-2.37
75	110.93	-1.42	-1.28	2459	-39.3	-1.59
76	106.41	-1.41	-1.33	3426	-35.7	-1.04
77	60.06	-0.60	-1.00	3588	-14.2	-0.39
78	127.14	-2.03	-1.60	3636	-45.0	-1.23
79	132.25	-2.25	-1.70	3311	-45.2	-1.36
80	150.94	-2.61	-1.73	4017	-47.2	-1.17
Australia coarse grain price (Aus $/MT)				Australia coarse grain exports (1000 MT)		
71	54.92	-0.04	-0.09	3101	-1.3	-0.04
72	68.98	-0.23	-0.33	2577	-5.6	-0.22
73	85.91	-0.61	-0.72	2786	-13.5	-0.48
74	89.21	-1.20	-1.34	2696	-22.3	-0.82
75	88.92	-1.27	-1.43	2851	-20.4	-0.71
76	94.37	-1.40	-1.48	2801	-19.7	-0.70
77	49.86	-0.61	-1.23	1797	-7.9	-0.44
78	105.73	-1.86	-1.76	3033	-22.4	-0.74
79	110.07	-2.06	-1.87	3100	-22.6	-0.73
80	124.83	-2.34	-1.88	2283	-23.1	-1.01

Table 5.2 (Continued)

Year	Base	Change	% Change	Base	Change	% Change
Thailand coarse grain price (baht/MT)				Thailand coarse grain exports (1000 MT)		
71	1433.54	-1.21	-0.08	2215	-0.37	-0.01
72	1875.72	-5.99	-0.31	1560	-1.77	-0.11
73	2755.23	-18.94	-0.68	2331	-4.86	-0.20
74	2858.41	-36.74	-1.28	2300	-7.57	-0.32
75	2582.16	-35.58	-1.37	2549	-6.96	-0.27
76	2552.64	-36.58	-1.43	2390	-6.87	-0.28
77	1251.02	-14.50	-1.15	1250	-2.53	-0.20
78	2646.13	-45.27	-1.71	2071	-7.33	-0.35
79	2696.09	-49.06	-1.81	2281	-7.22	-0.31
80	3116.95	-57.14	-1.83	2283	-7.03	-0.30
South Africa coarse grain export (1000 MT)						
71	2883	0	0			
72	3178	0	0			
73	3866	0	0			
74	2800	0	0			
75	1708	0	0			
76	3006	0	0			
77	3442	0	0			
78	2307	0	0			
79	3653	0	0			
80	5286	0	0			

substantial governmental market intervention and other obstacles that tend to prevent frictionless adjustments to changes in the underlying economic structure of the market. If exchange rates and coarse grain prices were determined in a perfectly free market, then the increase in import demand (as a result of the dollar depreciation) would tend to counterbalance the effect of the depreciation over time. The world gold market is a free market and therefore, the price of gold reacts more dramatically to an increase in the U.S. money supply than other variables. Consequently, the "USSR price" is affected more by this shock than is Japan's price.

The increase in the growth of the U.S. money supply also affects the markets of other coarse grain exporting countries (except South Africa) adversely. Both their exports and prices decrease as expected. However, the share of the adjustment accounted for by each country depends upon the relative sizes of their elasticities of price transmission and price elasticities of export supply. In any event, the overall share of world coarse grain exports by these countries, as well as their export revenues declines.

Table 5.3 presents the long-run or dynamic multipliers in percentage terms. In essence, these are long-run elasticities because they indicate the percent change in price, exports and imports from the given percent change in money supply over the period. Chambers and Just (1982)

Table 5.3. Dynamic elasticities of the sustained 5 billion dollar increase in U.S. money supply[a]

Country	Long-run[b] price impact	Long-run[b] export or import impact	Market Share[c]	
			Base	Simulation
USA	0.0924	0.2055	71.57	72.89
Argentina[d]	-0.7371 (-0.7448)	-0.3225 (-0.3189)	11.27	10.62
Canada	-0.4938	-0.3720	5.13	4.77
Australia	-0.5487	-0.2416	3.99	3.82
S. Africa	0.0	0.0	4.87	4.87
Thailand	-0.5194	-0.1015	3.18	3.02
Japan	-0.4743	0.1086	20.67	20.67
USSR	-0.9699	0.6088	8.89	9.06

[a] These are dynamic multipliers calculated in percentage forms which can be interpreted as long-run elasticities (see p. 171).

[b] Calculated at the same mean over the period 1971-1980.

[c] Share as a percent of the six largest exports.

[d] For corn and sorghum, respectively.

calculated such elasticities for a nonlinear, quarterly, closed U.S. corn-soybean-wheat model. The complication is that in a nonlinear model such as this, or Chambers and Just (1982), the sizes of dynamic multipliers depend upon the sizes of the variations of the exogenous variable. In linear models, the same multipliers would be obtained regardless of the size of the shock. Furthermore, the multipliers would be the same whatever the initial value of the endogenous variables of interest. This would not necessarily be the case in a nonlinear model. In a nonlinear model, large variations in the exogenous variable could yield different multipliers than a small variation, and those multipliers would also differ for different starting values of the endogenous variables of interest. For this reason, dynamic multipliers for nonlinear models should be presented together with information about how they were calculated. In this case, the variation is a constant linear growth of the U.S. money supply (five billion dollars each year) for the period 1971-1980.

The long-run elasticities in Table 5.3 are particularly interesting. In the long-run, such an expansionary monetary policy leads to inelastic responses of prices, imports and exports in the world coarse grain market. However, the U.S. coarse grain price responds much less than the prices in other countries to the U.S. money supply expansion while world trade (exports and imports) responds by less than prices in non-U.S. regions (see Table 5.3). This phenomenon can best be explained by an examination of the price elasticities of the export supplies and import demands of the world coarse grain market participants.

As the estimated elasticities reported in Chapter IV indicate, the world net excess coarse grain demand is fairly inelastic. This was, of course, expected for the policy reasons given in Chapter II. The major coarse grain importing nations of the world are developed countries which are highly protective of their markets. Therefore, the shift in the U.S. coarse grain export supply curve as a result of the change in U.S. monetary policy brings about a small change in the quantity of coarse grain traded in world markets and a relatively larger change in the prices of importing regions.

The price response in exporting regions, however, depends upon the export supply elasticities. The U.S. export supply is elastic (3.2)[1] resulting in a very small increase in the U.S. coarse grain price (0.09%). The price responses of the other exporting regions are comparatively larger

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[1]Calculated by dividing the long-run quantity impact by the long-run price impact (Table 5.3).

than that of the U.S. because their export supplies are much less price elastic than that of the U.S. The price responses outside the United States are much larger, in percentage terms, than the U.S. price response because of the high price elasticity of the U.S. export supply combined with the low price elasticity of the net import demand facing the United States.

Chambers and Just (1982) and Schuh (1983) claim that U.S. monetary policy has particularly dramatic and probably adverse effects on U.S. agricultural exports and prices. However, such an effect on export requires a price-elastic net import demand facing the United States. At the same time, a large effect of monetary policy on U.S. prices requires a price-inelastic U.S. export supply. In contrast, this study suggests that the import demand for coarse grains facing the United States is inelastic (rather than elastic) and that the U.S. coarse grain export supply is quite elastic (rather than inelastic). As a consequence, monetary policy has a relatively small effect on both U.S. prices and exports of coarse grains.

CHAPTER VI. SUMMARY, CONCLUSIONS, AND SUGGESTIONS FOR FURTHER RESEARCH

The general concern of this study was the effect of U.S. monetary policy on the U.S. agricultural sector. The specific objectives were to investigate the nature of U.S. monetary policy (during 1960-1980), to investigate the channels through which U.S. monetary policy influences world agricultural markets, and, finally, to conceptualize a world coarse grain market with which to evaluate the impact of U.S. monetary policy on agriculture. The study also provides a qualitative description of the world coarse grain market structure and existing policies affecting the market.

This study followed the monetary approach to exchange rate determination to construct a world model of the coarse grain market which included six major exporting countries--the U.S., Argentina, Canada, Australia, South Africa, and Thailand--and two major importing countries--Japan, and the USSR. Other importing countries entered the model exogenously. The nonlinear, nonspatial equilibrium model explicitly included the domestic sector of the U.S. coarse grain market while only considering the world market behavior of other world market participants through reduced form, net trade equations. Prices in the model were connected in a manner which accounted for the policies used by other exporting and importing regions.

The estimation of the model utilized data for the 1960-1980 period. The estimation technique utilized to derive the structural coefficients was nonlinear, truncated, two stage least squares with principal components. The estimation algorithm was from the SAS-ETS program. The model contained 76 exogenous variables and 41 equations including behavioral relationships, market clearing identities, and technical relationships. The major endogenous variables were U.S. feed, nonfeed, and inventory demands and supply and all regions' prices and net trades. The estimated behavioral equations had acceptable statistical properties. The estimated directional relationships among variables coincided *a priori* with expectations. The validation of the model through historical simulation proved satisfactory. also converged to equilibrium after an exogenous shock indicating that the model was stable. The model also tracked turning points of variables well. Some important conclusions concerning the world coarse grain market based on the empirical analysis are discussed below.

First, the U.S. acreage planted is inelastic with respect to prices of the previous period. Corn acreage responds significantly to corn diversion policy and is influenced by the acreage planted of the last period indicating a slow adjustment to changing economic incentives.

Second, U.S. feed, nonfeed, and inventory demands are all price inelastic (-0.36, -0.59, and -0.73, respectively). Feed demand is elastic with respect to the included livestock related variables. Nonfeed demand is influenced by demand in the previous period indicating the importance of exponentially growing technology. The inventory demand is influenced by transaction and speculative demands. However, the influence of coarse grain production on inventory demand seems to be almost as important as the price.

Third, the U.S. exchange rate is found to be determined in a monetary environment. The money supply of both the U.S. and the importing country are found to have nearly identical effects on the exchange rate. The elasticity of the exchange rate is about -0.68 with respect to the U.S. money supply and 0.4 with respect to the U.S. interest rate. Interest rates apparently influence the value of the exchange rate as suggested by monetary theory. The U.S. discount rate, however, appears to have more effect than that of Japan.

Fourth, in the category of the importing regions, the USSR demand for coarse grain imports is elastic with respect to its production and price. In addition, the gold price of the U.S. dollar is shown to have a large effect on Soviet decisions to import. Japan, however, is completely dependent on imports (100 percent of its consumption) and demonstrates very little response to price changes. On the other hand, Japan's livestock sector and rice production influence its trading behavior significantly. In addition, it is also found that Japan allows near perfect transmission of the changes in the world coarse grain market conditions into its domestic economy.

Fifth, all exporting regions except South Africa, allow for perfect transmission of the changes in world market conditions. The South African government, on the other hand, isolates its market completely from the world market. The estimated price elasticities of exports are 0.601 for Argentina's corn, 0.21 for Argentina's sorghum, 1.307 for Canada, 0.769 for Australia, 0.0 for South Africa, and 0.266 for Thailand. Not surprisingly, variables closely related to the livestock sector such as livestock price, grain consuming animal units, or income are found to influence the trading behavior of these regions significantly.

The major objective of this study is to evaluate the world market impacts of U.S. monetary policy. Consequently, the effects of a 5 billion dollar sustained increase in the U.S. money supply is simulated dynamically. The differences between the new levels of the endogenous variables in the model and their base values are taken as the specific impacts of such a policy change upon those variables. The percentage impacts and the long-run elasticities are also calculated for the key variables. The more interesting results from this simulation are summarized below.

First, the excess supply of money created in the monetary sector tends to depreciate the value of U.S. currency. Depreciation makes U.S. coarse grain more price competitive in international markets and the products of the export competing regions less so. The associated increase in demand for U.S. coarse grain, however, leads to only a relative small increase in the domestic U.S. price and exports from the U.S. This occurs because of the relatively high U.S. export supply elasticity and the relatively low elasticity of the net import demand facing the United States.

Second, world market prices decrease by relatively more than the U.S. price increases leading to a reduction in the exports of competing regions and a small improvement in the competitive position of the U.S. in the world market.

These results are particularly interesting in the light of recent attempts to tighten the U.S. money supply. Apparently, such a policy does not have dramatically adverse effects on U.S. coarse grain exports. In addition, the response of the domestic U.S. coarse grain market is also fairly minor. Therefore, contractionary monetary policy has only a small effect on the domestic U.S. coarse grain market.

This study provides some important information concerning the largely unexplored relationship between agriculture, in general, and the monetary sector. A few very recent studies have found that fluctuations in monetary variables affect the U.S. agricultural sector because the exchange rate itself is a monetary variable. While the results of this study suggest that these effects are small in the world coarse grain market, one must bear in mind that the agricultural markets in this model are linked to the monetary sector only through the U.S. exchange rate determination process. With little doubt, the effects reported here would be magnified if the interest rate, capital market and other linkages were specified.

The model developed in this study can be used to evaluate the consequences of specific policy issues of interest influencing the world coarse grain market. The model includes all the major trading participants. However, certain extensions of the model would allow additional policy analyses in other desired areas. These might include the following:

(1) to include the influence of changes in U.S. monetary policy on the industrial and other sectors of the U.S. macroeconomy which would likely affect the demand for coarse grain;

(2) to include the effect of the U.S. discount and corresponding interest rates on coarse grain production. The interest rate level determines, to a large extent, the amount farmers borrow to finance either the purchases of new land and equipment or the actual planting of coarse grain. Such effects, coupled with those specified in this study may be too large to be ignored;

(3) to endogenize explicitly the domestic markets of the other regions in the model. For example, all other exporting regions in this study are capable of producing more coarse grain than they do. Endogenizing coarse grain production in these regions might influence the results considerably;

(4) to endogenize the livestock sectors in each region. Coarse grain is used largely as a livestock feed. Consequently, the demand for coarse grain is derived from the demand for feed by the livestock sector. Endogenizing the livestock sector of each region would better reflect the forces which influence coarse grain markets;

(5) to remove the implicit assumption in this study that the exchange rates of the other regions are exogenous. The monetary policies of these regions are also important in the determination of the impact of U.S. monetary policy. The monetary policy actions of these other regions may also offset the effects of the policies pursued in the United States; and

(6) to consider the effect of monetary policy on other sectors of U.S. agriculture which would promote an important and interesting test of the results of this study.

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APPENDIX A: DEFINITIONS OF COMMODITIES AND COUNTRIES IN THE WORLD COARSE GRAIN MARKET

The term "feed grains" normally refers to the four low-protein grains fed to livestock--corn, barley, oats, and sorghum. The term "coarse grain" generally includes the four feed grains and rye, a high protein grain. Bjarnason (1967) and Collins (1977) demonstrate that corn, barley, oats, and sorghum are very close substitutes as animal feeds, while rye is mostly used as food. They also argue that prices of feed grains have a very high positive correlation. For this reason, and the difficulty of obtaining rye data for U.S. trade partners, the term "coarse grain" as used in this study refers only to corn, barley, oats, and sorghum. Aggregation of these grains on a metric ton basis does not pose serious problems.

The classification of countries into coarse grain exporting and importing regions as used in this study is provided in Table A1.

Table A1. Classification of countries into export and import regions of the world

Position	Region	Countries
Exporter	1. USA	United States
	2. ARG	Argentina
	3. CAN	Canada
	4. ASL	Australia
	6. SAF	South Africa
	6. THI	Thailand
Importer	Developed Economies (DC)	
	7. EEC9	Belgium and Luxembourg, Denmark, France, Ireland, Italy, Netherlands, United Kingdom, West Germany
	8. JAP	Japan
	9. OWE	Rest of DC's: Austria, Finland, Greece, Iceland, Israel, Malta, Norway, Portugal, Spain, Sweden, Switzerland, New Zealand
	Centrally Planned (CP)	
	10. USSR	Soviet Union
	11. China (PRC)	People's Republic of China
	12. Eastern Europe (EE)	Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, Yugoslavia
	Rapidly Developing Economies (LDCR)	
	13. OPEC	Algeria, Equador, Indonesia, Iran, Iraq, Kuwait, Libra, Nigeria, Saudi Arabia, Venezuela
	14. NONOPEC	Brazil, Hong Kong, Mexico, Singapore, South Korea, Taiwan

Table A1 (Continued)

Position	Region	Countries
	<u>Moderately Developing Economies</u>	
	15. LDCM	Afghanistan, Angola, Bangladesh, Bolivia, Burma, Camaroon, Cambodia, Chile, Colombia, Costa Rica, Cuba, Cyprus, Dahomey, Dominican Republic, Egypt, El Salvador, Ethiopia, Guatemala, Guinea, Guyana, Haiti, Honduras, India, Indonesia, Ivory Coast, Jamaica, Jordan, Kenya, Lebanon, Malagasy Republic, Malawi, Malaysia, Morocco, Mozambique, Nepal, Nicaragua, Niger, N. Korea, Outer Mongolia, Pakistan, Panama, Paraguay, Peru, Philippines, Rhodesia, Rwanda, Senegal, Somali Republic, South Yemen, Sri Lanka, Sudan, Syria, Tanzania, Tobago, Trinidad, Tunisia, Turkey, Uganda, Upper Volta, Uruguay, Venezuela, Vietnam, Zaire, Zambia

APPENDIX B: MODIFIED USSR PRICE LINKAGE EQUATION

The "USSR coarse grain price" initially utilized in this study was the calculated U.S. coarse grain price in terms of gold, i.e.,

$$PRICE10_t = \frac{CWP1_t}{PRGOLD78_t}$$

where

$PRICE10_t$ = "the USSR coarse grain price", ounces/MT;

$CWP1_t$ = the U.S. coarse grain price, US \$/MT;

$PRGOLD78_t$ = price of gold in dollars, US \$/ounce.

While $CWP1_t$ is endogenous in the model, the gold price of the dollar was exogenous leading to perverse results for Soviet imports in the U.S. monetary policy simulation. Consequently, an alternative equation was used to endogenize the gold price. The equation was specified as follows:

$$LOGPR_t = f(\overset{(-)}{LE8US_t}, \overset{(+)}{LLOGPR_t}, \overset{(+)}{DUMG_t})$$

where

LOGPR = natural log of gold in U.S. \$ (\$ U.S./ounce);

LE8US = natural log of the yen/U.S. dollar exchange rate;

LPR = lag of the dependent variable;

DUMG = dummy to account for the shift from fixed to flexible exchange rates in 1973.

The premise here is that gold is an investment commodity that reacts to changes in the U.S. dollar value of foreign currency. For example, if the U.S. money supply is expected to grow faster, then there would be a shift in portfolio assets from dollars into gold, which would increase the gold price. The lagged gold price captures the speed of adjustment. Under the Bretton-Woods system, the U.S. supported the gold price of the dollar. Consequently, changes in the U.S. money supply did not affect the gold price or U.S. dollar value of foreign currencies. As was explained in Chapters I and II, the adoption of flexible exchange rates contributed to the increase in the world money supply, making gold a more favorable asset.

The nonlinear estimation of this equation, within the model, produced the following results:

$$
\begin{array}{llll}
LOGPR_t = & 16.58 & -\ 2.56*LE8US_t & +\ 0.579*LLOGPR_t \\
& (7.68) & (-7.80) & (7.91) \\
& & [-2.56] & [0.579] \\
& +\ 0.396*DUMG & & \\
& (4.99) & &
\end{array}
$$

$$R^2 = 0.9865 \quad DW = 3.04$$

where the t-statistics are reported in parentheses and the elasticity in brackets.

The statistical properties of this equation are good with almost 99 percent of the historical variation explained. All variables have the correct sign and are significant at the .02 percent level.